

Relations between emotional awareness and alexithymia measures: Behavioral and neurobiological evidence

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The present work is the first to examine the behavioral and the neurobiological correlates of trait emotional awareness and alexithymia which are related personality constructs. Both traits are essential for understanding the abilities and deficits of psychosomatic patients to regulate emotions. However, to date little is known about their behavioral and neurobiological correlates. Therefore, the present dissertation addresses the relation between both constructs. The introduction section give an extensive overview of the available behavioral and neurobiological research. Based on the revealed literature, open research questions are identified and addressed in one psychometric and one imaging study. In study 1 the psychometric properties and relations between two different methods of measuring alexithymia and one measure of emotional awareness were evaluated. The 20-Item Toronto Alexithymia Scale (TAS-20), the Toronto Structured Interview for Alexithymia (TSIA), and the Levels of Emotional Awareness Scale (LEAS), which is a performance-based measure of emotional awareness, were administered to 84 university students. Study 2 addressed automatic brain reactivity to emotional stimuli as a function of trait emotional awareness. During scanning, happy, angry, fearful, and neutral facial expressions were subliminally presented to 46 healthy subjects, who had to rate the fit between artificial and emotional words. The results of the studies are summarized and integrated in the existing literature. Finally, open research questions are discussed, implications for future research are outlined.

¹Dazu kommen 141 zusätzliche Referenzen in den angeführten Originalartikeln

²Dazu kommen 7 Abbildungen in den angeführten Originalartikeln

³Dazu kommen 6 Tabellen in den angeführten Originalartikeln

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Chapter 1

Introduction

The best and most beautiful things in the world cannot be seen or even touched. They must be felt with the heart.

Helen Keller (1880–1968)
An American author

Understanding emotion and its regulation is arguably the main challenge of the psychosomatic medicine for 21st century. Unveiling the phenomenological, physiological and neurobiological correlates of emotion will necessarily advance our understanding of the relationship between emotion and bodily processes. Especially, in psychosomatic patients the relation between emotion and bodily processes seems to be disentangled (Lane,2008;Waller & Scheidt,2004). To study this relation psychosomatic research has predominately focussed on constructs such as alexithymia (Taylor, Parker, Bagby, & Bourke,1996), suppression (Scheier & Bridges,1995), type C personality (Temoshok et al.,2008) and type D personality (Denollet, Pedersen, Vrints, & Conraads,2006). All these constructs have a common denominator involving negative emotions which are not consciously experienced and therefore regulated in a way leading to somatic complaints. Moreover all these constructs focus on deficits in the inability to experience and regulate emotions and are mainly assessed by self-report measures. However, the use of self-report in the context of alexithymia and emotional awareness assumes (as basic prerequisite) valid judgments about one's ability to monitor and report on internal emotional states (Lane et al.,1996;Lane, Sechrest, Riedel, Shapiro, & Kaszniak,2000;Gündel, Ceballos-Baumann, & Von Rad,2000;Suslow, Kersting, Ohrmann, & Arolt,2001). Especially for high degrees of alexithymia this assumption might be violated because individuals may be unable to accurately rate their deficits in emotional awareness (Lane et al.,2000). Therefore, in order to understand emotion and its regulation in the case of alexithymia, first a valid measurement approach relying not only on self-report but also on more objective measures such as interviews and performance tasks are needed. Second, after a valid measurement approach has been identified and evaluated, the neurobiological correlates of alexithymia and emotional awareness have to be understood. Research addressing the neurobiological correlates of alexithymia has predominantly focused on controlled or explicit processing of emotional information. Several regions have been highlighted as altered in alexithymia, especially

the anterior cingulate cortex (Lane, Ahern, & Schwartz,1997), the insula (Bird et al.,2010;Kano et al.,2003;Ihme et al.,2013), and the fusiform gyrus (Karlsson, Naatanen, & Stenman,2008). Thus, research on controlled emotion processing suggests impairments in several cortical areas as a function of alexithymia. However, according to Zajonc's (1980) affective primacy hypothesis, initial responses to emotional stimuli are automatic and do not necessarily require conscious awareness (Critchley et al.,2000;Morris et al.,1998;Suslow et al.,2013;Whalen et al.,1998;Winkielman, Knutson, Paulus, & Trujillo,2007). While there are several studies on controlled emotion processing in alexithymia, only a few neuroimaging studies have addressed the automatic brain reactivity to emotional information as a function of alexithymia. So far several structures have been highlighted as altered in alexithymia, especially the amygdala, fusiform gyrus, insula, superior temporal gyrus, middle occipital, temporal, and parahippocampal gyrus (Kugel et al.,2008;Eichmann, Kugel, & Suslow,2008;Reker et al.,2010;Duan, Dai, Gong, & Chen,2010). However, all of the above-mentioned imaging studies on automatic emotion processing used self-report to measure alexithymia. To date, no neuroimaging or behavioral study has examined automatic emotion processing as a function of alexithymia or emotional awareness as measured with interview or performance task. Therefore, the aim of the present dissertation is to explore the relations between two measures of alexithymia and one of emotional awareness by applying a multi-method approach in a German healthy sample. Further, the dissertation also explores the behavioral and the neurobiological correlates of automatic emotion processing as a function of traits alexithymia and emotional awareness.

Chapter 2

Theoretical part

2.1 Alexithymia

Alexithymia is a personality trait characterized by deficits in identifying and describing feelings accompanied by an externally oriented cognitive style and mundane fantasies (Sifneos,1973;Taylor & Bagby,2004). The construct was first introduced by Nemiah, Freyberger, and Sifneos (1976) to describe clinical patients with psychosomatic problems who experience difficulties describing their emotions and who exhibit impoverished mental representations of their emotional states. According to Taylor and Bagby (2004) alexithymia is normally distributed in the general population. Its prevalence rate in the general population is estimated to be around 10% (Franz et al.,2008). The etiology of alexithymia is unclear. Alexithymic features have been related to socialization factors such as an emotional neglect in early childhood (Aust, Härtwig, Heuser, & Bajbouj,2013). There is also evidence for genetic dispositions (Kano et al.,2012). Several neurobiological explanations also exist. Accordingly alexithymia has been considered as a deficit in the right hemispheric processing (Jessimer & Markham,1997), a callosal transfer deficit (Hoppe & Bogen,1977;Grabe et al.,2004) or a dysfunction of the anterior cingulate cortex (Lane,2008;Lane et al.,1997;Wingbermhühle, Theunissen, Verhoeven, Kessels, & Egger,2012). In summary, the etiology of alexithymia seems to be caused by multiple factors.

2.1.1 Measures of alexithymia

The most frequently used instrument to assess alexithymia is the 20-Item Toronto Alexithymia Scale (TAS-20) (Bagby, Parker, & Taylor,1994). The TAS-20 is comprised of three factor scales that assess three salient facets of the alexithymia construct: difficulty identifying feelings (DIF), difficulty describing feelings (DDF), and externally oriented thinking (EOT). The psychometric properties of the TAS-20 have been frequently demonstrated (Bagby, Parker, & Taylor,1994;Beresnevaité, Taylor, & Bagby,2007). However, the use of self-report in the context of alexithymia assumes (as basic prerequisite) valid judgments about one's ability to monitor and report on internal emotional states (Lane et al.,1996;Gündel et al.,2000;Suslow et al.,2001). Especially for high degrees of alexithymia this assumption might be vio-

lated because individuals may be unable to accurately rate their deficits in emotional awareness (Lane et al.,2000). Therefore, many authors recommended the use of a multi-method approach in order to enhance future alexithymia research by avoiding influence of specific method-based response biases associated with mono-method assessment (Taylor & Bagby,2004;Bagby, Taylor, Parker, & Dickens,2006;Kano & Fukudo,2013;Lane et al.,1997;Lumley, Gustavson, Partridge, & Labouvie-Vief,2005).

The Rorschach Alexithymia Scale (RAS) (Porcelli & Mihura,2010) is a performance based measure of alexithymia. The RAS is scored with the Rorschach Comprehensive System (CS) (Exner,2003), and was originally developed to measure alexithymia in a more indirect (i.e. objective) manner. The RAS correlates strongly with the TAS-20 in clinical samples (Porcelli & Mihura,2010). Relations between RAS and other measures of alexithymia still need to be studied.

Another alternative non-self-report measure of alexithymia is the Toronto Structured Interview for Alexithymia (TSIA) (Bagby et al.,2006). The TSIA is an observer rated interview for assessing alexithymia. More importantly, TSIA includes a scale measuring imaginal processes (e.g., fantasies, daydreams) which are key features of alexithymia but not included in the present version of the TAS-20 (Bagby, Parker, & Taylor,1994). In the development of the TSIA and its initial validation with psychiatric outpatients and community participants, the TSIA demonstrated adequate item characteristics, a significant correlation with the TAS-20, and adequate inter-rater, internal, and retest reliability (Bagby et al.,2006;Grabe et al.,2009;Carette et al.,2009;Meganck, Inslegers, Vanheule, & Desmet,2011).

The modified Beth Israel Hospital Psychosomatic Questionnaire (M-BIQ) (Bagby, Taylor, & Parker,1994) is another observer-based measure of alexithymia. The M-BIQ is a twelve-item scale. Six of the items assess the ability to identify and verbally communicate feelings (i.e. emotional awareness), and six items measure imaginal activity and externally oriented thinking (i.e. operatory thinking). The M-BIQ correlates significantly (positively) with other measures of alexithymia such as the TAS-20 (Bagby, Taylor, & Parker,1994;Meganck et al.,2011) and the TSIA (Meganck et al.,2011).

One potential weakness of observer-based measures, however lies in the capacity to produce reliable ratings of respondents' answers across different interviewers and/or raters (Bagby et al.,2006). Nevertheless, structured interviews allow to probe or explore a response, and thereby clarify or (de)contextualize a respondent's answer, leading to a more accurate account of the meaning or nature of the subject's 'true' response (Bagby et al.,2006;Trull, Widiger, Useda, & Holcomb,1998;Zimmerman,1994).

2.1.2 Clinical and behavioral correlates of alexithymic tendencies

Alexithymia is considered a vulnerability factor for (or at least a correlate of) several psychiatric and psychosomatic disorders including depression (Honkalampi, Tanskanen, Lehtonen, & Viinamaki,2000;Vanheule, Desmet, Verhaeghe, & Bogaerts,2007), dissociation (Grabe, Rainermann, Spitzer, Gäsicke, & Freyberger,2000;Zlotnick et al.,1996), and eating disorders (Taylor et al.,1996). Furthermore, alexithymia

seems associated with lower life satisfaction (Mattila et al.,2011), poorer social skills (Meganck, Vanheule, Inslegers, & Desmet,2009;Spitzer, Siebel, Barnow, Grabe, & Freyberger,2005;Vanheule, Desmet, Meganck, & Bogaerts,2006), attachment related anxiety and avoidance (Karukivi, Tolvanen, Karlsson, & Karlsson,2014), higher suicide rates (Hintikka et al.,2004), non-use of professional help for anxiety (Rufer, Moergeli, Moritz, Drabe, & Weidt,2014), and poorer therapy outcome (Rasting, Brosig, & Beutel,2005). Therefore, understanding the behavioral and neurobiological correlates of this personality trait is of great clinical significance.

Most of the behavioral studies on alexithymia⁴ included explicit or controlled tasks of emotional information processing (i.e., affect labeling tasks, matching tasks, and detection tasks).

Affect labeling tasks requires subjects to select among several emotional labels the one that best fits a particular expression (Grynberg et al.,2012). Mann, Wise, Trinidad, and Kohanski (1994) showed that high alexithymics have impairments in labeling facial expressions, particularly for sadness. Likewise, Jessimer and Markham (1997) found that high alexithymics have lower labelling performances than low alexithymics for all basic emotions. Similar results have been also reported by Swart, Kortekaas, and Aleman (2009). In another study Ihme et al. (2014) found that alexithymic features are associated with increased reaction times for negative (i.e., angry and fearful) faces, but not with labeling accuracy. No differences in labeling accuracy between high and low alexithymics were reported in other studies (Pandey & Mandal,1997;Prkachin, Casey, & Prkachin,2009).

Matching task refers to the identification of a previously presented target face among distractors (Grynberg et al.,2012). Lane et al. (1996) found an association between alexithymia and impaired verbal and nonverbal recognition of emotion stimuli. Further, Lane et al. (2000) showed that alexithymia is associated with poorer verbal and nonverbal recognition of emotion stimuli irrespective of the emotion itself.

Detection tasks involve the selective identification of an emotional expression among other sequentially presented expressions (emotional or neutral) and relies mainly on visuoperceptual abilities (Grynberg et al.,2012). Prkachin et al. (2009) showed that alexithymia is negatively correlated with sensitivity scores for each basic emotion, suggesting deficits in perception of emotion in alexithymia. In another study Parker, Prkachin, and Prkachin (2005) showed that especially DDF scale of TAS-20 was associated with decreasing sensitivity scores for negative, but not neutral faces in a detection task under temporal constraints.

There are also several studies that included implicit or automatic tasks of emotional information processing (i.e., affective priming tasks).

Affective priming tasks requires subjects to rate the emotional valence of a neutral stimulus (e.g. the target), which has been preceded by briefly (i.e. 33ms) presented emotional stimulus (e.g. the prime). Compared to neutral expression, happy facial expression are expected to elicit more positive evaluations of subsequently presented stimuli, whereas negative facial expression are expected to lead to more negative evaluations of subsequently presented stimuli. This phenomenon of affect congruent influence of emotional facial expression on subsequent judgments is called affective priming effect (Suslow et al.,2013). Yet, none of the studies on auto-

⁴Only studies conducted with healthy subjects are included.

matic emotion processing (Kugel et al.,2008;Eichmann et al.,2008;Reker et al.,2010) found significant behavioral differences as a function of alexithymia. This might be due to the lack of significant priming effects in these studies. Or the method used to measure alexithymia (i.e. self-report). However, research (Asendorpf, Banse, & Mücke,2002;Strack & Deutsch,2004;Schmukle & Egloff,2005;Suslow et al.,2010) suggested that self-report measures predict more controlled behaviors whereas objective tests predict more spontaneous behaviors. It must also be acknowledged that these affective priming studies used a one-dimensional decision task that consisted of evaluative judgments about neutral faces (as expressing negative or positive feelings). Research on the structure of affective experiences indicates that positive and negative affect represent independent dimensions (Larsen, McGraw, & Cacioppo,2001) which should be examined separately.

In summary, alexithymia seems associated with deficits in the detection and matching of emotional stimuli. However, these deficits seem to vary as function of the stimulus exposure (i.e. time constraints). So far no behavioral deficits in the processing of briefly presented emotional stimuli (e.g. affective priming task) in alexithymia have been observed. However, several possible explanations have been discussed.

2.1.3 Neurobiological correlates of alexitymic tendencies

The neurobiological correlates of alexithymic tendencies are less understood. Research addressing the neural correlates of alexithymia has predominantly focused on controlled or explicit processing of emotional information.

As a result several regions have been highlighted as altered in alexithymia, especially the anterior cingulate cortex (Lane et al.,1997), the insula (Bird et al.,2010;Kano et al.,2003;Silani et al.,2008), and the fusiform gyrus (Karlsson et al.,2008). Thus, research on controlled emotion processing suggests impairments in several cortical areas as a function of alexithymia. However, according to Zajonc's (1980) affective primacy hypothesis, initial responses to emotional stimuli are automatic and do not necessarily require conscious awareness (Zajonc,1980;Critchley et al.,2000;Morris et al.,1998;Suslow et al.,2013;Whalen et al.,1998;Winkielman, Zajonc, & Schwarz,1997). While there are several studies on controlled emotion processing in alexithymia, even less is known about automatic emotion processing in the context of alexithymia. Only a few neuroimaging studies have addressed the automatic brain reactivity to emotional information as a function of alexithymia. Amygdala and fusiform gyrus reactivity to masked sad faces was found to be negatively correlated with alexithymia (Kugel et al.,2008;Eichmann et al.,2008). Reker et al. (2010) reported an inverse association between alexithymia and brain activation in amygdala, insula, superior temporal gyrus, middle occipital, and parahippocampal gyrus to masked happy and sad faces. These results have been extended by Duan et al. (2010) who observed that alexithymia is negatively correlated with neural response to masked surprised faces in the superior temporal gyrus, fusiform gyrus, and parahippocampal gyrus. Except Duan et al. (2010), all of the above-mentioned studies on automatic emotion processing applied the affective priming paradigm. None of them found significant relationships between alexithymia and shifts in implicit affect due to

masked facial emotion. This might be due to the lack of significant priming effects in these studies. It must also be acknowledged that these affective priming studies used a one-dimensional decision task that consisted of evaluative judgments about neutral faces (as expressing negative or positive feelings). Research on the structure of affective experiences, indicates that positive and negative affect represent independent dimensions (Larsen et al.,2001) which should be examined separately. Moreover all of the above-mentioned neuroimaging studies on automatic emotion processing used self-report to measure alexithymia. However, many authors (Bagby et al.,2006;Lumley et al.,2005) recommend the use of interviews or other psychometric approaches to improve validity of alexithymia assessment.

2.2 Emotional awareness

A personality construct closely related to alexithymia is trait emotional awareness. Trait emotional awareness is a cognitive skill reflecting individual differences in the ability to recognize and describe emotion in oneself and others (Lane, Quinlan, Schwartz, Walker, & Zeitlin,1990). Lane and Schwartz (1987) proposed a model of emotional-cognitive development that differentiates between five levels of emotional development. The five levels in ascending order are awareness of physical sensations (level 1), action tendencies (level 2), single emotions (level 3), blends of emotions (level 4), and blends of blends of emotions (level 5, the capacity to appreciate complexity in the experiences of self and other persons). The five levels of emotional awareness are hierarchically related, in that, functioning at each level adds to and modifies the function of previous levels but, importantly, does not eliminate them (Lane,2008). For example, blends of emotion (Level 4 experiences), compared with action tendencies (Level 2), are assumed to be associated with more differentiated representations of somatic sensations (Level 1). The feelings associated with a given emotional response can be viewed as a construction consisting of each of the levels of awareness up to and including the highest level attained (Tavares, Barnard, & Lawrence,2011;Lane & Garfield,2005). The trait level of function is the level at which a given individual typically functions (Lane,2008). A fundamental tenet of this model is that individual differences in emotional awareness reflect variations in the degree of differentiation and integration of schemata used in emotional processing. Fundamental information for such emotional processing schemata can be derived from the external world or the internal world through introspection (Lane & Schwartz,1987).

2.2.1 Measures of emotional awareness

A performance-based task, the Levels of Emotional Awareness Scale (LEAS; Lane et al., 1990), has been developed to measure trait emotional awareness. The LEAS is a written performance test that asks a person to describe his or her feelings (LEAS-S (Self)) and those of other people (LEAS-O (Other)). The total score⁵ ranges from

⁵In the present study we used the short version of LEAS consisting of ten vignettes. Therefore the total score ranged from 0 to 50.

0 to 100, with higher scores indicating higher emotional awareness. In contrast to the alexithymia measures (i.e. TAS-20 and TSIA) LEAS is not designed to measure deficits in the identifying and describing of feelings, but focussing on the abilities to describe and identify feelings. Moreover, different than alexithymia, emotional awareness reflects not only individual differences in the ability to recognize and describe emotions in oneself but in others as well.

2.2.2 Clinical and behavioral correlates of emotional awareness

Previous studies have shown that emotional awareness is related to greater ego development and greater cognitive complexity when describing parents (Lane et al.,1990), better global emotional recognition (Lane et al.,2000), and better prediction of changes in emotional awareness due to psychotherapeutic treatment (Subic-Wrana, Bruder, & Thomas,2005). One of the advantages of the LEAS is that the scale is not related to self-reported negative affectivity (e.g., depression or anxiety) (Subic-Wrana et al.,2005).

2.2.3 Neurobiological correlates of emotional awareness

Research addressing the neural correlates of emotional awareness has focused exclusively on controlled or explicit processing of emotional information. Lane et al. (1998) found evidence that individual differences in trait emotional awareness may at least in part be a function of the degree to which the anterior cingulate cortex (ACC) participates in the experiential processing and response to emotional cues. Similarly, McRae, Reiman, Fort, Chen, and Lane (2008) found positive correlations between emotional awareness and activity in the dorsal ACC, middle frontal gyrus, primary somatosensory cortex, inferior frontal gyrus, and insula during the processing of highly arousing, as opposed to less arousing, emotional stimuli. The findings of both studies support the idea that individual differences in emotional awareness are associated with increased ACC activity, which according to McRae et al. (2008) may reflect greater attentional processing of emotional information. They also suggest that individuals with higher emotional awareness are better able to process highly arousing emotional stimuli. Thus, research on controlled emotion processing suggests heightened activity in several cortical areas implicated in attention allocation and arousal as a function of trait emotional awareness. So far there are no studies that addressed the neural correlates of automatic emotion processing as a function of emotional awareness.

2.3 Multi-method approach of assessing alexithymia and emotional awareness

Following a multi-method approach to assess alexithymia and emotional abilities, Lumley et al. (2005) explored the factorial structure of several methods (self-report, observer-rating, interview, performance task, and emotional intelligence test) in a

sample of college students. The authors proposed and tested several factor structures. For example, assuming that self-report measures allow unique access to emotional processes by introspection that is not provided by other methods of alexithymia measurement it is possible that they may load in factor analyses separately from more objective measurement methods. According to the two-factor model explicitly measured (i.e. subjective) alexithymia (using self-report or interview) should be differentiated from implicitly measured alexithymia (e.g., using performance tests). Explicit tests assess a trait directly by asking one to report directly

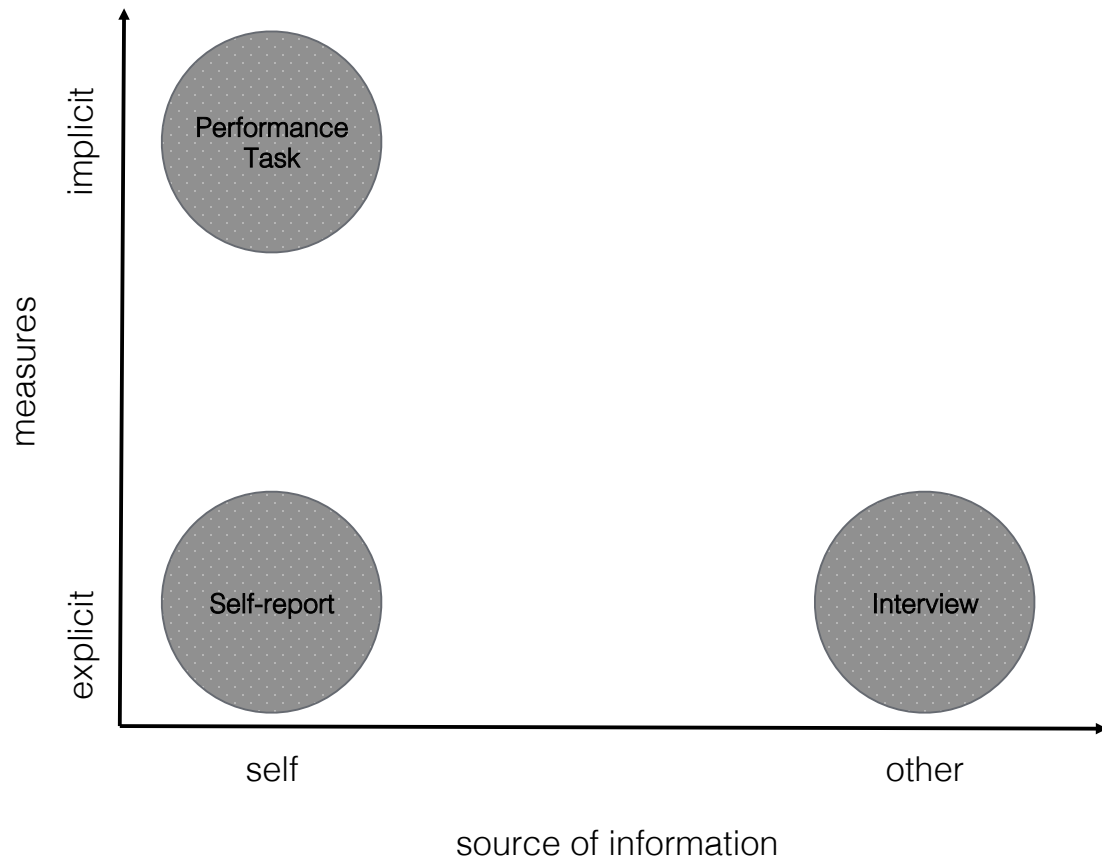


Figure 2.1: *Multi-method approach of assessing alexithymia. Adopted from Lumley et al. (2005).*

on his/her emotional abilities. In contrast, implicit measures are indirect and require inferences of the ability, for example, from behavioral performance that is thought to reflect emotional ability. In this view, self-reports and interviews can be classified as direct measures whereas performance tasks represent indirect measures. Finally, one can combine the above-mentioned distinctions with another dimension: the source of the information. Some information is provided by the subject itself (self) and some is provided by observers (others). Therefore, theoretically in the present work a three-factor solution can be expected in which the direct self measure (e.g. TAS-20) can be distinguished from the indirect self measure (e.g. LEAS) and the direct other measure (e.g. TSIA). Lumley et al. (2005) found evidence that a three factor-solution represents their multi-method data best in which the measures were

divided into explicit self-provided tests, explicit other-provided tests, and implicit self-provided tests. However, in their study, they included only one measure of alexithymia and one measure of emotional awareness. Therefore, this model must be extended and replicated with more than one measure of alexithymia and emotional awareness. The model of Lumley et al. (2005) is depicted in figure 2.1. In another multi-method study on alexithymia, Meganck et al. (2011) found that two factorial structure represent the data best. However, in their study Meganck et al. (2011) did not include performance-based measures. In summary, there only two studies to date that investigated the interrelation between different measures of alexithymia and emotional awareness. The study by Lumley et al. (2005) which included only one measure of alexithymia and the study by Meganck et al. (2011) which did not included performance measures or measures of emotion awareness. Therefore, the multi-method approach of alexithymia and emotional awareness must be further tested and evaluated.

2.4 Hypotheses

In summary, the reveled literature on the measurement of alexithymia and emotional awareness suggests the use of multi-method approach. However, to date there are only two studies that applied more than one measure of alexithymia or emotional awareness. Therefore, the first aim of the present dissertation is to examine the relations between two different methods of alexithymia assessment and a measure of emotional awareness in a non-clinical sample: TAS-20 (self-report), TSIA (interview), and LEAS (performance task). Based on the study of (Lumley et al.,2005), it was hypothesized that:

H1 In the factor analyses all three measures will be reflected by three different factors: explicit-self, explicit-other, and implicit-self.

Regarding the behavioral correlates higher degrees of alexithymia and lower degrees of emotional awareness seem associated with deficits in the detection and matching of emotional stimuli presented explicitly (i.e. without visual constraints). So far no deficits in the processing of briefly presented emotional stimuli (i.e. presented for 33 ms) in alexithymia has been observed. One possible explanation is that all studies so far used self-report to assess alexithymia. Past research (Asendorpf et al.,2002;Strack & Deutsch,2004;Hofmann, Gawronski, Gschwendner, Le, & Schmitt,2005) showed that self-report measures predict more controlled behaviors whereas objective tests predict more spontaneous behaviors such as snap decision in the case of affective priming paradigm. However, to date there is no study to test the affective priming paradigm by using more objective measures of alexithymia or emotional awareness. Therefore, the following hypotheses were postulated and tested:

H2 It was hypothesized that both alexithymia and emotional awareness are related to altered behavioral performance in the affective priming task.

H3 It was expected that emotional awareness (i.e. performance task) is a better predictor of automatic emotion processing at behavioral level than alexithymia as measured by self-report or interview.

With respect to the neurobiological correlates of alexithymia and emotional awareness research so far has predominantly focused on controlled or explicit processing of emotional information. Accordingly less is known about the automatic emotion processing in the context of alexithymia. Up to date several areas have been emphasized as altered in alexithymia, especially the amygdala, fusiform gyrus, insula, superior temporal gyrus, middle occipital, temporal, and parahippocampal gyrus (Kugel et al.,2008;Eichmann et al.,2008;Reker et al.,2010;Duan et al.,2010). Presently, there is no imaging study to address automatic emotion processing as a function of trait emotional awareness or alexithymia as measured differently than with a self-report. Further, none of the existing imaging studies found significant behavioral effects. That limits significantly the interpretations of the available studies. For that reason the present dissertation introduces a new innovative paradigm⁶ combining affective priming task with items of the "Implicit Positive and Negative Affect Test" (IPANAT) (Quirin, Kazén, & Kuhl,2009). That way the present dissertation is expected to be the first to show significant priming effects and neurobiological effects at the same time. Further the following hypotheses are postulated:

- H4** It was hypothesized that low trait emotional awareness and high alexithymia⁷. are related to decreased reactivity in brain structures implicated in the automatic emotion processing especially in the amygdala, the insula, superior temporal gyrus, the fusiform gyrus, the inferior frontal gyrus, the primary somatosensory cortex, the thalamus, and the middle occipital gyrus.
- H5** It was hypothesized that emotional awareness (i.e. performance task) is a better predictor of brain reactivity of automatic emotion processing than alexithymia as measured by self-report or interview.

⁶For more information see study 2 of the empirical section.

⁷Due to journal restrictions in the accepted article (Study 2) only results on emotional awareness are reported. However, in this dissertation additional findings on alexithymia are presented.

Chapter 3

Empirical part

This dissertation is based on two original research articles, which are included as published in the remainder of this chapter.

3.1 Study 1: Assessing alexithymia and emotional awareness: Relations between measures in a German non-clinical sample

Reference

Lichev, V., Rufer, M., Rosenberg, N., Ihme, K., Grabe, H., Kugel, H., Donges, U., Kersting, A., & Suslow, T. (2014). Assessing alexithymia and emotional awareness: Relations between measures in a German non-clinical sample. *Comprehensive Psychiatry*, 55(4), 952–959.

Assessing alexithymia and emotional awareness: Relations between measures in a German non-clinical sample

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Abstract

The aim of this study was to evaluate psychometric properties and relations between two different methods of measuring alexithymia and one measure of emotional awareness in a German non-clinical sample. The 20-Item Toronto Alexithymia Scale (TAS-20), the Toronto Structured Interview for Alexithymia (TSIA), and the Levels of Emotional Awareness Scale (LEAS), which is a performance-based measure of emotional awareness, were administered to 84 university students. Both internal reliability and inter-rater reliability for the TSIA were acceptable. Results from exploratory factor analysis (EFA) based on all measures supported a three factorial solution previously obtained in an American sample using multiple methods of alexithymia and emotional ability measurement. In our three factor model direct self (TAS-20), direct other (TSIA), and indirect self (LEAS) measures were differentiated. The convergent validity of the TSIA was supported by a significant correlation with the LEAS. Our findings suggest that future research on alexithymia and emotional awareness can benefit from the use of a multi-method approach and should include objective measures.

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1. Introduction

Alexithymia is a personality trait characterized by deficits in identifying and describing feelings accompanied by an externally oriented cognitive style and mundane fantasies [1,2]. According to Taylor and Bagby [1] alexithymia is normally distributed in the general population. Its prevalence rate in the general population is estimated to be around 10% [3]. Alexithymia is considered a vulnerability factor for (or at least a correlate of) several psychiatric and psychosomatic disorders including depression [4], dissociation [5,6], and eating disorders [7]. Furthermore, alexithymia seems associated with lower life satisfaction [8], poorer social

skills [9–11], higher suicide rates [12] and poorer therapy outcome [13].

The most frequently used instrument to assess alexithymia is the 20-Item Toronto Alexithymia Scale (TAS-20) [14]. The TAS-20 is comprised of three factor scales that assess three salient facets of the alexithymia construct: difficulty identifying feelings (DIF), difficulty describing feelings (DDF), and externally oriented thinking (EOT). The psychometric properties of the TAS-20 have been frequently demonstrated [14,15]. However, the use of self-report in the context of alexithymia assumes (as basic prerequisite) valid judgments about one's ability to monitor and report on internal emotional states [16–19]. Especially for high degrees of alexithymia this assumption might be violated because individuals may be unable to accurately rate their deficits in emotional awareness [17]. Therefore, many authors recommended the use of a multi-method approach in order to enhance future alexithymia research by avoiding influence of specific method-based response biases

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associated with mono-method assessment [1,20–23]. The Levels of Emotional Awareness Scale (LEAS) [24] is a performance-based measure of emotional awareness. According to Lane and Schwartz [25], emotional awareness, is a cognitive skill reflecting individual differences in the ability to recognize and describe emotion in oneself and others. Indeed, difficulties in the identification and verbalization of emotions in oneself are considered important components of alexithymia. Previous studies have shown that emotional awareness as measured by the LEAS is related to greater ego development and greater cognitive complexity when describing parents [24], better global emotional recognition [17], and better prediction of changes in emotional awareness due to psychotherapeutic treatment [26]. One of the advantages of the LEAS is that the scale is not related to self-reported negative affectivity (e.g., depression or anxiety) [26].

The Rorschach Alexithymia Scale (RAS) [27,28] is a performance based measure of alexithymia. The RAS is scored with the Rorschach Comprehensive System (CS) [29], and was originally developed to measure alexithymia in a more indirect (i.e. objective) manner. The RAS correlates strongly with the TAS-20 in clinical samples [27]. Relations between RAS and other measures of alexithymia still need to be studied. Another alternative non-self-report measure of alexithymia is the Toronto Structured Interview for Alexithymia (TSIA) [20]. The TSIA is an observer rated interview for assessing alexithymia. More importantly, the TSIA includes a scale measuring imaginal processes (i.e. fantasies and daydreams) which are key features of alexithymia but not included in the present version of the TAS-20 [14]. In the development of the TSIA and its initial validation with psychiatric outpatients and community participants, the TSIA demonstrated adequate item characteristics, a significant correlation with the TAS-20, and adequate inter-rater, internal, and retest reliability [20,30–33]. The modified Beth Israel Hospital Psychosomatic Questionnaire (M-BIQ) [34] is another observer-based measure of alexithymia. The M-BIQ is a twelve-item scale. Six of the items assess the ability to identify and verbally communicate feelings (i.e. emotional awareness), and six items measure imaginal activity and externally oriented thinking (i.e. operatory thinking). The M-BIQ correlates significantly (positively) with other measures of alexithymia such as the TAS-20 [34,35] and the TSIA [35]. One potential weakness of observer-based measures, however, lies in the capacity to produce reliable ratings of respondents' answers across different interviewers and/or raters [20]. Nevertheless, structured interviews allow to probe or explore a response, and thereby clarify or (de)contextualize a respondent's answer, leading to a more accurate account of the meaning or nature of the subject's 'true' response [20,36,37].

Measures of alexithymia and emotional awareness have been developed mostly independently from each other. There are few studies on alexithymia and emotional awareness in which more than one measure or method was

administered simultaneously [16,17,23,26,33]. Little is known about how these different methods of alexithymia and emotional awareness measurement are related to each other. Self-reported alexithymia (TAS-20) has been found to show small to moderate correlations with interview based alexithymia, for example with TSIA [20,30,32,33], and with M-BIQ [35], with correlations being higher in the clinical than the non-clinical samples. Alexithymia as measured by TAS-20 has been reported to have low (inverse) correlations with performance-based measures of emotional awareness such as the LEAS [17], but high (positive) correlations with performance-based measures of alexithymia (i.e. the RAS) [27]. There are few studies that addressed the relation between interview-based measures of alexithymia. For example, Meganck et al. [35] found a large correlation between TSIA and M-BIQ in a clinical sample. The associations between interview-based measures of alexithymia and performance-based measures of alexithymia and emotional awareness are less understood. For example, Lumley et al. [23] found no relation between M-BIQ and LEAS. The association between LEAS and TSIA still needs to be investigated. Another issue that has to be clarified is if one or more factors underlie different alexithymia and emotional awareness measures.

Following a multi-method approach to assess alexithymia and emotional abilities, Lumley et al. [23] explored the factorial structure of several methods (self-report, observer-rating, interview, performance task, and emotional intelligence test) in a sample of college students. The authors proposed and tested several factor structures. For example, assuming that self-report measures allow unique access to emotional processes by introspection that is not provided by other methods of alexithymia measurement it is possible that they may load in factor analyses separately from more objective measurement methods. According to the two-factor model explicitly measured (i.e. subjective) alexithymia (using self-report or interview) should be differentiated from implicitly measured alexithymia (e.g., using performance tests). Explicit tests assess a trait directly by asking one to report directly on his/her emotional abilities. In contrast, implicit measures are indirect and require inferences of the ability, for example, from behavioral performance that is thought to reflect emotional ability. In this view, TAS-20 and TSIA can be classified as direct measures whereas LEAS represents an indirect measure. Finally, one can combine the above-mentioned distinctions with another dimension: the source of the information. Some information is provided by the subject itself (self) and some is provided by observers (others). Thus, theoretically a three-factor solution can be expected in our study in which the direct self measure TAS-20 can be distinguished from the indirect self measure LEAS and the direct other measure TSIA. Lumley et al. [23] found evidence that a three factor-solution represents their multi-method data best in which the measures were divided into explicit self-provided tests, explicit other-provided tests, and implicit self-provided tests.

In another multi-method study on alexithymia, Meganck et al. [35] found that two factorial structure represents the data best. However, in their study Meganck et al. [35] did not include performance-based measures.

In the present study we examined the relations between two different methods of alexithymia assessment and a measure of emotional awareness in a non-clinical sample: TAS-20 (self-report), TSIA (interview), and LEAS (performance task). Based on the study of Lumley et al. [23], it was hypothesized that a three factorial solution may best represent the data. Furthermore, since the psychometric properties of the German version of the TSIA have not yet been evaluated in a non-clinical sample, its reliability and convergent validity were assessed.

2. Methods

2.1. Participants

The sample consisted of 84 (39 women; mean age = 23.8 years, $SD = 2.8$) university students. None of the participants suffered from current mental disorders or had any lifetime history of psychiatric condition according to the criteria of DSM-IV [38], as assessed with the Structured Clinical Interview for DSM-IV Axis I disorders [39]. The procedure of the study was approved by the ethics committee of the Medical School of the University of Leipzig and was in accordance with the declaration of Helsinki. All participants gave their written voluntary informed consent to participate in the study. Participants were recruited during various seminars and lectures at the University of Leipzig and at the Institute of Technology, Economics and Culture (HTWK, Leipzig). The screening procedure and the psychological assessment of the participants lasted on average about three hours. For their participation in the study participants received about 30 euros. There were no drop-outs due to missing data.

2.2. Measures

2.2.1. 20-item Toronto Alexithymia Scale

The 20-Item Toronto Alexithymia Scale [14,40] was used as a self-report measure of alexithymia. The total scores range from 20 to 100, with higher scores indicating greater alexithymia. The instrument includes three sub-scales: difficulty identifying feelings (DIF), difficulty describing feelings (DDF), and externally oriented thinking (EOT).

2.2.2. Toronto Structured Interview for Alexithymia

The Toronto Structured Interview for Alexithymia [20] is an interview-based observer rated measure of alexithymia [German version: 30,31]. The interview consists of 24 questions, which relate to difficulties identifying feelings (DIF), difficulties describing feelings (DDF), externally oriented thinking (EOT), and limited imaginal processes (IMP). The items are scored by trained interviewer on a

three-point scale. The total scores range between 0 and 48, with higher scores indicating greater alexithymia.

2.2.3. Levels of Emotional Awareness Scale

The Levels of Emotional Awareness Scale (LEAS) [24,25] assesses trait emotional awareness. The LEAS is a written performance test that asks a person to describe his or her feelings (LEAS-S (Self)) and those of other people (LEAS-O (Other)). In the present study we used the short version of LEAS [24,25] with ten vignettes. The total score ranges from 0 to 50, with higher scores indicating higher emotional awareness.

2.3. Interviewers and procedures

Two interviewers (NR, VL) conducted the TSIA ratings. The interviews were carried out at the Department of Psychosomatic Medicine and Psychotherapy of the University of Leipzig. The interviewers were required to become familiar with the alexithymia construct by reading a book chapter on affect dysregulation and alexithymia [41] and a manual outlining administration and scoring procedures for the TSIA (Bagby et al., unpublished manual for the TSIA). The manual has been given to the authors by the German translators of the TSIA in agreement with the authors [20] of the original version. All interviewers were also trained in the administration and scoring of the interview by one of the translators (MR) of the German version of the TSIA in Zurich, including discussion of the scoring guidelines and the correct use of prompts and probes. All interviews were video recorded for the assessment of inter-rater reliability. We were unable to compute interclass correlations because level of measurement was ordinal. Moreover, we had only two raters. Therefore, to assess level of agreement between raters the weighted kappa coefficient was applied. Estimates exceeding 0.60 are considered to represent adequate inter-rater reliability [42]. Additionally, we used Spearman's rank correlation coefficient as a second independent measure of agreement. Interviews were conducted on an individual basis and lasted approximately 90 min. Subjects completed the German versions of the TAS-20 and the LEAS before the TSIA interview. The interviewers were not informed about TAS-20 and LEAS total or subscale scores.

2.4. Exploratory factor analysis

To explore how many latent variables underlie the correlational patterns between the manifest variables we performed a principal component analysis (PCA) on the alexithymia (and emotional awareness) measures. Some authors [43–46] suggested subjects-to-variables (STV) ratio no lower than 5 in order to maintain a minimum sample size for exploratory factor analyses. Based on this criterion we restricted the analysis to the total and subscale scores, resulting in an STV ratio of 7. The PCA was conducted in two steps. First, we used a statistical procedure called *Parallel Analysis* [47] as criterion for determining the

number of components. This procedure involves extracting eigenvalues from random data sets that parallel the actual data set with regard to the number of cases and variables. The eigenvalues derived from the actual data are then compared to the eigenvalues derived from the random data. It is recommended to use the eigenvalues that correspondent to the 95th percentile of the distribution of random data eigenvalues [45–50]. Components are retained as long as the i th eigenvalue from the actual data exceeds the i th eigenvalues from the random data. As additional criterion we used the scree test [51] in combination with the eigenvalue criteria (≥ 1). In a second step, we then carried out a PCA with varimax rotation by extracting a fixed number of components as revealed by the parallel analysis and the scree plot criteria (see Results).

3. Results

3.1. Descriptive Statistics

For all alexithymia measures, mean scores, standard deviations, ranges, and internal consistencies are presented in Table 1. For the TSIA, scores were comparable with those of other studies with non-clinical samples [20]. Moreover, scores as measured by TAS-20 and LEAS were also comparable to those of previous studies [3,52]. Concerning the reliability of the measures, the Cronbach alpha coefficients for the TAS-EOT, the LEAS-Other, and the TSIA-DIF scales were below the standards ($< .70$). All other scales showed an adequate internal consistency.

3.2. Exploratory factor analysis

The results of the parallel analysis and the scree test based on the total and subscale scores suggested the extraction of

Table 1

Descriptive statistics: means, standard deviations, ranges, and internal consistencies for the measures of alexithymia and emotional awareness.

Scales	Mean	SD	Range	Cronbach's Alpha
TAS-20 total	46.7	10.1	26–70	0.82
TAS-DIF	13.8	5.2	7–29	0.85
TAS-DDF	13.0	4.5	5–24	0.85
TAS-EOT	19.9	3.2	13–29	0.63
TSIA total	14.2	9.1	1–37	0.92
TSIA-DIF	1.04	1.8	0–8	0.69
TSIA-DDF	2.15	5.0	0–11	0.88
TSIA-EOT	5.01	3.2	0–12	0.80
TSIA-IMP	6.04	3.0	0–11	0.82
LEAS total	36.1	5.1	27–46	0.80
LEAS-S	31.3	4.6	21–39	0.70
LEAS-O	30.0	4.6	17–38	0.64

N = 84. TAS-20: 20-Item Toronto Alexithymia Scale; DIF: difficulty identifying feelings; DDF: difficulty describing feelings; EOT: externally oriented thinking; TSIA: Toronto Structured Interview for Alexithymia; IMP: impaired imaginal processes; LEAS: Levels of Emotional Awareness Scale; LEAS-S: self score; LEAS-O: other score.

Table 2

Parallel analysis (Monte-Carlo test) for determining significant eigenvalues.

Component	Eigenvalues raw data	Mean eigenvalues random data	95% eigenvalues random data
1	5.12	1.67	1.84
2	2.49	1.48	1.60
3	1.65	1.34	1.44
4	.98	1.21	1.30
5	.58	1.11	1.18
6	.40	1.01	1.08
7	.37	.92	.98
8	.20	.83	.90
9	.15	.74	.81
10	.05	.66	.73
11	.00	.57	.64
12	.00	.47	.55

Components are retained as long as the i th eigenvalue from the raw data exceeds the i th eigenvalues from the random data.

three components (see Tables 2 and 3 and Fig. 1). These three components explained 77.2% of the variance. Each measure loaded on a separate component, probably reflecting different measurement approaches to the constructs (see Table 3).

3.3. Correlations between alexithymia and emotional awareness measures

Table 4 shows the Pearson correlations between measures of alexithymia, emotional awareness, and their sub-scales. All correlations $r > .22$ were statistically significant at $p = .05$ (two-tailed). As expected, for all measures total scores were strongly related to their subscales. TSIA total score was more strongly related to

Table 3

Factor loadings of the alexithymia and emotional awareness measures (TAS-20, TSIA, LEAS): Three factor solution (principal component analysis, varimax rotation with kaiser normalization).

	F1	F2	F3
TSIA total	.97	–.24	.36
TSIA-DIF	.76	–.10	.26
TSIA-DDF	.84	–.03	.32
TSIA-EOT	.87	–.24	.28
TSIA-IMP	.71	–.37	.31
TAS-20 total	.49	.98	–.02
TAS-DIF	.26	.90	–.12
TAS-DDF	.45	.85	–.02
TAS-EOT	.49	.46	.16
LEAS total	–.73	.20	.94
LEAS-S	–.65	.23	.87
LEAS-O	–.59	.20	.88

N = 84. Factor loadings ≥ 0.40 are considered significant and depicted in bold. TAS-20: 20-Item Toronto Alexithymia Scale; DIF: difficulty identifying feelings; DDF: difficulty describing feelings; EOT: externally oriented thinking; TSIA: Toronto Structured Interview for Alexithymia; IMP: impaired imaginal processes; LEAS: Levels of Emotional Awareness Scale; LEAS-S: self score; LEAS-O: other score.

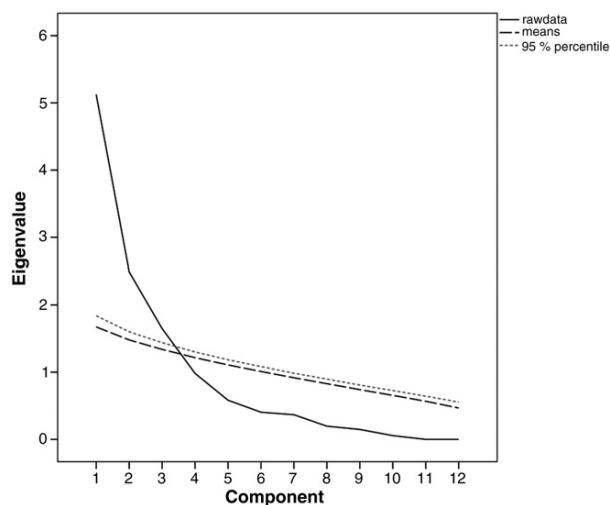


Fig. 1. Scree plot depicting number of alexithymia components to retain. The *Parallel Analysis* procedure was used as criterion for determining the number of components. This procedure involves extracting eigenvalues from random data sets that parallel the actual data set with regard to the number of cases and variables. The eigenvalues derived from the actual data are then compared to the eigenvalues derived from the random data. The threshold is where the eigenvalues from the raw data are greater than the 95th eigenvalue from random data. In the present sample the decision was to retain three components.

LEAS ($r = -.47$) than to TAS-20 ($r = .23$). According to Fishers' z-test, these two correlations differed significantly in magnitude ($z = 1.76$, $p < .05$ (one-tailed)). In contrast, the LEAS total score was not significantly related to the TAS-20 total score ($r = -.20$). Interestingly, the TSIA and LEAS total scores were related to the TAS-EOT subscale. Moreover the TSIA-DIF scale was not significantly related to the TAS-DIF scale $r = .16$, $p > .05$. This correlation is not significantly different from the correlation between TSIA-DIF and TAS-DIF reported in a community sample

[20] $r = .29$, $p < .01$. According to Fishers' z-test, these two correlations did not differ significantly in magnitude ($z = -.97$, $p > .16$ (one-tailed)).

3.4. Inter-rater reliability

For a subsample of $n = 50$ interviews, the estimated weighted kappa for the TSIA total score was $k = .67$. The correlation between the ratings of both interviewers was $r_s = .76$. Both coefficients suggest an adequate level of agreement between raters.

4. Discussion

In the present study we evaluated interrelationships and psychometric properties of different methods of alexithymia and emotional awareness measurement in a German sample of university students. We investigated the number of factors that underlie the three measures. Based on the results from a previous study [23] it was hypothesized that a three-factor structure may best represent the data. The present results corroborate this hypothesis. The mean values obtained for all three measures were comparable to those of previous studies [3,20,26,33].

To our knowledge, this is the first study to explore the psychometric properties of the TSIA in a German-speaking non-clinical sample. Importantly, the inter-rater reliability and the internal consistency for the TSIA interview were adequate. In view of our findings and those of Grabe et al. [30], it can be concluded that the TSIA can be administered reliably in German-speaking clinical and non-clinical samples.

In our study, the correlation between TSIA and TAS-20 was rather small but significant. The magnitude of the correlation is comparable with correlations found in a Canadian community sample in the original validation study of the TSIA [20]. The magnitude of the observed correlation is also comparable with correlations between

Table 4
Zero-order correlations between measures of alexithymia and emotional awareness.

Scale	1	2	3	4	5	6	7	8	9	10	11	12
1. TSIA total		.79	.87	.91	.72	-.47	-.43	-.36	.23	.01	.24	.37
2. TSIA-DIF			.81	.64	.30	-.40	-.35	-.27	.23	.16	.23	.13
3. TSIA-DDF				.73	.39	-.41	-.35	-.29	.34	.16	.34	.32
4. TSIA-EOT					.57	-.48	-.43	-.36	.21	-.05	.22	.43
5. TSIA-IMP						-.27	-.29	-.22	0.11	-.16	.01	.27
6. LEAS total							.88	.83	-.20	-.09	-.18	-.23
7. LEAS-S								.63	-.14	-.04	-.13	-.18
8. LEAS-O									-.13	-.06	-.14	-.11
9. TAS-20										.86	.84	.56
10. TAS-DIF											.61	.24
11. TAS-DDF												.26
12. TAS-EOT												

$N = 84$. Correlations $r > .22$ are significant at $p = 0.05$ (two-tailed). TAS-20: 20-Item Toronto Alexithymia Scale; DIF: difficulty identifying feelings; DDF: difficulty describing feelings; EOT: externally oriented thinking; TSIA: Toronto Structured Interview for Alexithymia; IMP: impaired imaginal processes; LEAS: Levels of Emotional Awareness Scale; LEAS-S: self score; LEAS-O: other score.

TAS-20 and other interview-based (e.g., modified Beth Israel Questionnaire) and observer-based (e.g., Alexithymia Observer Scale) measures of alexithymia in a sample of university students as described by Lumley et al. [23]. It must be also noted that the low correlations generally obtained between OAS and other alexithymia measures are likely due to the fact that the OAS contains many items that assess correlates of alexithymia rather than the core features of the construct. Moreover, it must also be acknowledged, that the correlation between self-reported alexithymia and observer-rated alexithymia tends to be higher in clinical samples [20,30,32,34,35]. In the present study, the TSIA was significantly related to the LEAS. The magnitude of this correlation was significantly higher than that between the TSIA and the TAS-20. TSIA and LEAS shared about 23% of their variance. As Lumley et al. [23] found no relations between LEAS and objective measures of alexithymia (i.e. M-BIQ and OAS) this is the first study to show an association between LEAS and an interview-based measure of alexithymia. One possible explanation for the higher amount of shared variance might be similarities in the measurement procedure; both instruments represent objective measures and require subjects to verbalize emotional reactions.

Interestingly, we observed that the EOT scale of the TAS-20 was significantly related to the objective measures of alexithymia and emotional awareness, especially the TSIA. This result is consistent with the findings of Lumley et al. [23] who reported a positive correlation between TAS-EOT and alexithymia as measured with the M-BIQ. In their study, the correlation between TAS-EOT and M-BIQ was strongest for the subscale *emotional awareness* of the M-BIQ. In our study, we had with the LEAS a direct measure of emotional awareness and found also a correlation between externally oriented thinking and emotional awareness. A possible additional explanation for the correlation of the TAS-EOT (but not TAS-DIF and TAS-DDF) with the objective measure of emotional awareness could be that the items of the EOT subscale do not require participants to make judgments about deficits concerning the experience and expression of emotions. Therefore, self-reporting on the EOT subscale may be more similar to an objective measure such as the LEAS [53]. Our results support the construct validity of the EOT subscale and underscore the important role of externally oriented thinking facet in the construct of alexithymia.

A somewhat surprising finding of the present study was the absence of correlation between TSIA-DIF and TAS-DIF scales. In our sample, this correlation was lower compared to that obtained in a Canadian community sample [20], however both correlations did not differ significantly from each other. One possible explanation may lie in the nature of our sample which consisted predominantly of young university students. Previous studies have shown [20,30] that this correlation tends to be substantially higher in clinical samples.

The present study is the first to provide evidence in favor of the convergent validity of the TSIA. The TSIA correlated significantly with a performance-based alexithymia related test (i.e. the LEAS), which requires participants to identify and describe their emotions (and those of others) in various situations. Another goal of the present study was to examine if the factor structure obtained by Lumley et al. [23] can also be found in our sample. The results of our exploratory factor analysis suggest the extraction of three factors. The factor structure revealed in our study is in line with a multi-method model of alexithymia and emotional ability measures as proposed by Lumley et al. [23]. In their study, the authors proposed and confirmed a three factor structure. The authors interpreted the factors as reflecting differences in the measurement approach and pointed out that the different measures may not relate to a unitary construct but differ as a function of the person providing the information (self vs. other) and whether the measure is direct or indirect. Similarly, we interpret the extracted components as reflecting different measurement approaches.

To conclude, in our study we found evidence that various measures of alexithymia and emotional awareness using different methodological approaches are only moderately associated. In our three factor model, direct self (TAS-20), direct other (TSIA), and indirect self (LEAS) measures were differentiated. These measurement instruments may capture different aspects of emotion recognition or emotional awareness but it appears that at least to some extent variation between measures can be explained by differences among assessment methods. The administered measures of alexithymia and emotional awareness seem not to be primarily related to a unitary construct but differ as a function of the source providing the information (self vs. other) and whether the measure is indirect or direct. Our findings suggest that future research on alexithymia and emotional awareness will benefit from the use of a multi-method approach and should include objective measures.

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3.2 Study 2: Automatic emotion processing as a function of trait emotional awareness: An fMRI Study

Reference

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Automatic emotion processing as a function of trait emotional awareness: an fMRI study

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It is unclear whether reflective awareness of emotions is related to extent and intensity of implicit affective reactions. This study is the first to investigate automatic brain reactivity to emotional stimuli as a function of trait emotional awareness. To assess emotional awareness the Levels of Emotional Awareness Scale (LEAS) was administered. During scanning, masked happy, angry, fearful and neutral facial expressions were presented to 46 healthy subjects, who had to rate the fit between artificial and emotional words. The rating procedure allowed assessment of shifts in implicit affectivity due to emotion faces. Trait emotional awareness was associated with increased activation in the primary somatosensory cortex, inferior parietal lobule, anterior cingulate gyrus, middle frontal and cerebellar areas, thalamus, putamen and amygdala in response to masked happy faces. LEAS correlated positively with shifts in implicit affect caused by masked happy faces. According to our findings, people with high emotional awareness show stronger affective reactivity and more activation in brain areas involved in emotion processing and simulation during the perception of masked happy facial expression than people with low emotional awareness. High emotional awareness appears to be characterized by an enhanced positive affective resonance to others at an automatic processing level.

Keywords: emotional awareness; implicit affect; automatic emotion processing; neuroimaging

INTRODUCTION

Trait emotional awareness is a cognitive skill reflecting individual differences in the ability to recognize and describe emotion in oneself and others (Lane *et al.*, 1990). Lane and Schwartz (1987) proposed a model of emotional-cognitive development that differentiates between five levels of emotional development. The five levels in ascending order are awareness of physical sensations (level 1), action tendencies (level 2), single emotions (level 3), blends of emotions (level 4) and blends of 'blends of emotions' (level 5, the capacity to appreciate complexity in the experiences of self and other persons). A fundamental tenet of this model is that individual differences in emotional awareness reflect variations in the degree of differentiation and integration of schemata used in emotional processing. Fundamental information for such emotional processing schemata can be derived from the external world or the internal world through introspection (Lane and Schwartz, 1987). A performance-based task, the Levels of Emotional Awareness Scale (LEAS; Lane *et al.*, 1990) has been developed to measure trait emotional awareness.

The five levels of emotional awareness are hierarchically related, in that, functioning at each level adds to and modifies the function of previous levels but, importantly, does not eliminate them (Lane, 2008). For example, blends of emotion (Level 4 experiences), compared with action tendencies (Level 2), are assumed to be associated with more

differentiated representations of somatic sensations (Level 1). The feelings associated with a given emotional response can be viewed as a construction consisting of each of the levels of awareness up to and including the highest level attained (Lane and Pollermann, 2002; Lane and Garfield, 2005). The trait level of function is the level at which a given individual typically functions (Lane, 2008).

The levels of emotional awareness can be mapped onto the distinction between implicit and explicit processes (Lane, 2000). Level 1 (bodily sensations) and Level 2 (action tendencies) phenomena are critical components of emotional responses but, viewed in isolation, cannot necessarily be considered indicators of emotions. The peripheral physiological arousal and action tendencies associated with emotion are 'implicit' in the sense that they occur automatically and do not require conscious processes to be executed efficiently. Levels 3, 4 and 5 consist of conscious (or *explicit*) emotional experiences at different levels of complexity. The levels of emotional awareness theory puts implicit and explicit processes on the same continuum. However, relatively little research has been completed that explores the details of the interactions across levels.

Research addressing the neural correlates of emotional awareness has focused exclusively on controlled or explicit processing of emotional information. Lane *et al.* (1998) found evidence that individual differences in trait emotional awareness may at least in part be a function of the degree to which the anterior cingulate cortex (ACC) participates in the experiential processing and response to emotional cues. Similarly, McRae *et al.* (2008) found positive correlations between emotional awareness and activity in the dorsal ACC, middle frontal gyrus, primary somatosensory cortex, inferior frontal gyrus and insula during the processing of highly arousing, as opposed to less arousing, emotional stimuli. The findings of both studies support the idea that individual differences in emotional awareness are associated with

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increased ACC activity, which according to [McRae *et al.* \(2008\)](#) may reflect greater attentional processing of emotional information. They also suggest that individuals with higher emotional awareness are better able to process highly arousing emotional stimuli. Thus, research on controlled emotion processing suggests heightened activity in several cortical areas implicated in attention allocation and arousal as a function of trait emotional awareness.

Evidence that higher emotional awareness is associated with top-down modulation of lower-level function comes from two different sources. Evidence for modulation of level 1 (somatic sensation) function comes from [Lane *et al.* \(2011\)](#), which demonstrated that patients at risk for sudden cardiac death owing to the Long QT Syndrome with higher levels of emotional awareness had more differentiated reporting of somatic symptoms in an ecological momentary assessment study. Evidence for modulation of level 2 (action tendency) function comes from [Bréjard and colleagues \(2012\)](#) who observed that adolescents with higher levels of emotional awareness were less impulsive. The latter finding is consistent with expectations, in that, level 2 function is action-oriented, whereas higher levels of emotional awareness include consideration of long-term consequences in addition to satisfaction of immediate needs. In these contexts, the correlates of trait emotional awareness were outcomes (symptoms, behaviors) that involved conscious reflection and attention, particularly among those who were more emotionally aware.

Less well studied is the bottom-up or input side of cross-level communication. To do so requires examination of the relation between trait emotional awareness and indices of lower-level functions at the moment of confrontation with emotional stimuli. Based on the findings by [McRae *et al.*](#) cited above it could be hypothesized that individuals who are more emotionally aware are more sensitive to emotional information and have more intense responses to emotion stimuli. Supporting evidence for this comes from research showing that trait emotional awareness is positively correlated with skin conductance responses to emotional stimuli ([Lane *et al.*, 2000a](#); [McRae *et al.*, 2008](#)). This means that greater trait emotional awareness is characterized by stronger peripheral physiological arousal in response to emotional stimuli. In an affective priming study ([Suslow *et al.*, 2001](#)), higher trait emotional awareness was associated with prolonged processing times during the automatic perception of lexical and facial emotion stimuli. These findings indicate that individuals with high trait emotional awareness automatically allocate more attention to emotional stimuli and react to them with greater physiological arousal. It could be that greater arousal amplifies the input signal and greater attentional processing enables the detection of greater complexity in that signal. This would be consistent with the theory that greater emotional awareness is associated with more complex emotion information processing due to the differentiation and integration of the schemata that participate in such processing, and would begin to explain the mechanisms by which individuals who are more aware are able to extract more information from exteroceptive emotional stimuli.

According to [Zajonc's \(1980\)](#) affective primacy hypothesis, initial responses to emotional stimuli are automatic and do not necessarily require conscious awareness. It is plausible that individuals with higher emotional awareness of their own and others' feelings could be characterized by stronger automatic reactions to emotional stimuli. The effortless production of responses in basal emotion processing systems of the brain such as the amygdala appears to provide an important basis of information for higher processing systems. In case higher-order neocortical areas receive poor input from the limbic and somatosensory system, mental representation and differentiation of emotional responses could be reduced. High automatic emotion responsivity could thus be an important factor in promoting the emotional development and differentiation of individuals.

To elicit unconscious affective reactions, researchers have used subliminal presentations of emotional facial expressions ([Zajonc, 2000](#)). It has been shown that masked happy and masked angry faces can cause positive or negative reactions that are not accessible to conscious awareness ([Winkielman *et al.*, 2005](#)). Subliminal perception of emotional facial expression is a complex process that implicates an interactive network of brain areas. Central neural structures underpinning automatic emotion perception from the face are the amygdalae, thalamus, occipito-temporal visual cortical regions (including the fusiform gyrus), the inferior frontal gyrus, the insula and the somatosensory cortices (e.g. [Killgore and Yurgelun-Todd, 2004](#); [Phillips *et al.*, 2004](#); [Liddell *et al.*, 2005](#); [Duan *et al.*, 2010](#); [Suslow *et al.*, 2010](#)). It has been shown that facial mimicry occurs even during subliminal perception of facial emotion ([Dimberg *et al.*, 2000](#); [Rotteveel *et al.*, 2001](#)). Observation of others' facial expression of emotions activates brain regions involved in experiencing similar emotions. The amygdala, insula and anterior cingulate gyrus participate in processes of emotion simulation ([Bastiaansen *et al.*, 2009](#); [Molenberghs *et al.*, 2012](#)).

In this study, we examined for the first time the relationship between trait emotional awareness and automatic brain reactivity to positive and negative facial emotions in healthy adults. It was hypothesized that high trait emotional awareness is related to increased reactivity in brain structures implicated in the processing of masked facial emotions. Moreover, we hypothesized that LEAS is positively related to affective priming effects (i.e. high emotional awareness should be associated with more shifts in implicit affect due to masked facial emotion compared with low emotional awareness). By administering the affective priming paradigm, we examined the relationship between trait emotional awareness and affective resonance at an automatic processing level. Affective resonance can be defined as a person's tendency to resonate and experience the same affect in response to viewing a display of that affect by another person. Affective resonance can be considered to be the original basis for interpersonal communication ([Tomkins, 1962](#)).

To increase the probability of occurrence of behavioral affective priming effects, we reduced visibility of primes compared with other studies (e.g. [Kugel *et al.*, 2008](#); [Reker *et al.*, 2010](#)) by using forward and backward masking. To examine the effects of emotional primes on implicit positive and negative affect separately, we combined affective priming based on facial expression with items of the 'Implicit Positive and Negative Affect Test' (IPANAT; [Quirin *et al.*, 2009](#)). The IPANAT has been shown to be a valid measure of implicit positive and negative affect ([Quirin *et al.*, 2009, 2011](#)). To evaluate the success of the masking procedure, participants took part in a forced-choice detection task outside the scanner.

METHOD

Participants

Fifty-two right-handed healthy volunteers participated in this functional magnetic resonance imaging (fMRI) study. Six participants had to be excluded from further analysis, five because of excessive head motion in the scanner (>3 mm translation) and one because of high depression score (Beck Depression Inventory, BDI ≥ 14). The final sample consisted of 46 participants (23 women; mean age = 23.5 years, s.d. = 2.7). None of the participants had current psychiatric illness or any lifetime history of psychiatric condition according to the criteria of Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; [APA, 1994](#)), as diagnosed with the Structured Clinical Interview for DSM-IV Axis I disorders ([Wittchen *et al.*, 1997](#)). Exclusion criteria of this study were any neurological abnormalities, head trauma or loss of consciousness, psychotropic medication and the standard magnetic resonance imaging contraindications.

Handedness of subjects was measured by the Handedness Questionnaire (Raczowski *et al.*, 1974). Visual acuity was tested before inclusion in the study. The local ethics committee approved the procedure of the experiment. All participants gave their written consent to participate in the study and were financially compensated on study completion.

The LEAS (Lane *et al.*, 1990; Subic-Wrana *et al.*, 2001) was administered as a measure of trait emotional awareness. The LEAS is a written performance task. The subject is asked to describe his or her feelings and those of other people. In this study, we used the short version of the LEAS with 10 vignettes. The mean LEAS total score was 35.9 (s.d. = 4.9). Cronbach's alpha for the LEAS total score was $\alpha = 0.73$. Higher scores on LEAS indicate higher emotional awareness. The BDI-II (Beck and Steer, 1987; Hautzinger *et al.*, 1994) was administered to assess current symptoms of depression. The mean BDI score was 3.0 (s.d. = 3.5; $\alpha = 0.78$). The State-Trait-Anxiety Inventory (STAI; Spielberger *et al.*, 1970; Laux *et al.*, 1981) was applied to assess trait anxiety. In this sample, the mean trait anxiety score was 33.7 (s.d. = 8.2; $\alpha = 0.89$). The Positive and Negative Affect Schedule (PANAS; Watson *et al.*, 1988; Krohne *et al.*, 1996) was used to measure trait positive affect (P) and trait negative affect (N). The mean score for PANAS-P was 16.2 (s.d. = 2.5; $\alpha = 0.83$). The mean score for PANAS-N was 6.22 (s.d. = 0.9; $\alpha = 0.73$).

fMRI experiment: stimulus materials and procedure

Colored photographs of 20 different individuals (Langner *et al.*, 2010) served as stimuli for the fMRI experiment. Four different emotional facial expressions (i.e. happy, angry, fearful and neutral) were applied as primes. Primes were shown with a sandwich masking technique using letter strings (see Figure 1). The letter strings were drawn randomly on each trial. The durations of the masks were chosen based on the results of a pilot study ($n = 10$) conducted in our laboratory. The experiment consisted of 80 trials: 20 per prime condition. Primes were presented with restriction of no repetition of an individual and no more than one repetition of a prime condition on consecutive trials. The lexical material for the evaluation of the fit between artificial word and emotion adjective was taken from the Implicit Positive and Negative Affect Test (IPANAT; Quirin *et al.*, 2009). We used five artificial words (SAFME, VIKES, TUNBA, TALEP and BELNI) and four adjectives: two were positive (happy, cheerful), two were negative (helpless, inhibited). The duration of each trial was 9 s. The trial started

with a fixation cross lasting for 800 ms. Then, the prime stimulus was presented (33 ms) forward and backward masked by the letter mask (duration 33 ms each). During the following 8.1 s, participants had to evaluate the fit between artificial and emotion word on a four-point Likert scale by pressing one of four buttons (0, 1, 2 or 3). For half of the subjects, higher number indicated higher fitting between artificial and emotion word. The other half of the subjects indicated higher fittings by pressing lower numbers. The shifts in implicit positive affect were calculated by subtracting implicit positive affect score for the neutral face condition from those of the happy face condition. Similarly, the shifts in implicit negative affect were calculated by subtracting implicit negative affect score for the neutral face condition from those of the angry or fearful face conditions.

During the fMRI session, participants lay supine in the scanner with extended arms holding fiber optic response pads with two buttons in each hand. Half of the subjects indicated better fit between artificial word and adjective by pressing the right buttons, half by pressing the left buttons. Word evaluations and reactions times were recorded. Subjects' head position was stabilized with cushions.

fMRI data acquisition and data analysis

Participants underwent structural and functional MRI scanning on a 3 T scanner (Magnetom Verio, Siemens, Erlangen, Germany) using a standard 12-channel head coil. For each participant, structural images were acquired with a T1-weighted 3D MP-RAGE (Mugler and Brookeman, 1990). Magnetization preparation consisted of a non-selective inversion pulse. The imaging parameters were $T_1 = 650$ ms, $TR = 1300$ ms, $TE = 3.5$ ms, flip angle = 10° , isotropic spatial resolution of 1 mm^3 , two averages. Blood oxygen level-dependent (BOLD) sensitive images were collected using T2*-weighted echo-planar imaging (EPI) sequence [matrix 64^2 ; 30 slices; resolution $3 \text{ mm} \times 3 \text{ mm} \times 4 \text{ mm}$; gap 0.8 mm ; repetition time (TR) = 2 s; echo time (TE) = 30 ms; flip angle (FA) = 90° ; interleaved slice acquisition; 400 images]. Scanning planes were oriented parallel to a line through the posterior and anterior commissures. fMRI data were analyzed using Statistical Parametric Mapping SPM5 (SPM5) (<http://www.fil.ion.ucl.ac.uk/spm/>). The initial five functional volumes were discarded to allow longitudinal magnetization to reach equilibrium. Functional volumes were slice time-corrected (middle slice as reference), realigned to the temporally first image and corrected for movement-induced image distortions (six-parameter rigid

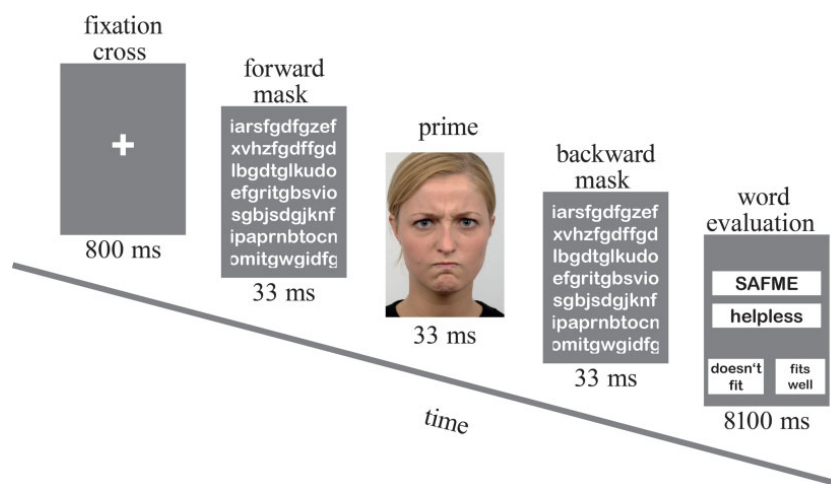


Fig. 1 Sequence of events within trials in the affective priming task. In our example, a trial with an angry prime is shown.

body affine realignment). Functional and anatomical images were co-registered. Anatomical images were then segmented, including normalization to a standard stereotaxic space using the T1 template by the Montreal Neurological Institute (MNI) delivered with SPM. The normalization parameters were then applied to the functional EPI series. On the functional data, spatial smoothing was performed using a three-dimensional Gaussian filter of 6 mm full-width at half-maximum.

We used an event-related design. For each participant, trials were averaged for each prime condition (happy, angry, fearful and neutral) resulting in four average trials for each subject. First level *t*-contrasts were calculated by contrasting each emotional condition to the neutral one (i.e. happy *vs* neutral, angry *vs* neutral and fearful *vs* neutral). Then one-sample *t*-tests were performed on activation data for the three emotion conditions (compared with the neutral face condition) to obtain main effects of emotions. Finally, the relationship between trait emotional awareness and brain activation during processing of masked facial emotions was evaluated [controlling for positive affectivity (PANAS-P)] using multiple regression as implemented in SPM5. In contrast to positive affectivity, negative affectivity (PANAS-N) did not change the fMRI findings, so the latter results are not further presented and discussed. The general linear model was used to model the effects of interest and other confounding effects.

First, region-of-interest (ROI) analyses were carried out focusing on the amygdala. It has been repeatedly shown that the amygdala is activated during the subliminal perception of facial emotion (e.g. Whalen et al., 1998; Dannlowski et al., 2007). The amygdala was defined according to Tzourio-Mazoyer et al. (2002), and the amygdala mask was created by means of the Wake Forest University (WFU) pickatlas (Maldjian et al., 2003). In the ROI analyses, significant clusters are reported corrected for search volume ($P < 0.05$). In addition, exploratory whole-brain analyses were conducted for each contrast using a statistical threshold of $P < 0.001$ (uncorrected) and a spatial extent of 10 contiguous voxels.

Detection task

To evaluate the success of the masking procedure, a forced-choice detection task was administered outside the scanner after the fMRI

experiment. The detection task had the same presentation conditions and the same stimuli as the fMRI experiment. The task consisted of 40 trials, 10 trials per emotion condition. Participants were presented with a photograph of an emotional face preceded and followed by pictures with letter strings (sandwich masking). Participants' task was to label the expression of the face. Subjects were informed that they would see facial expressions depicting happy, angry, fearful, sad and neutral emotions (though sad faces were actually not shown) and asked to indicate which prime was presented between the two letter masks via button press. The non-parametric index of sensitivity A' proposed by Aaronson and Watts (1987) was used to assess detection performance. It represents an extension of the sensitivity index defined by Grier (1971) and is appropriate for signal detection tasks in which the false alarm rate exceeds the hit rate. The A' index takes into account hit and false alarm rates and indicates chance performance at $A' = 0.5$. We calculated a sensitivity index for each facial expression condition (e.g. happy) relative to the other conditions (in this example *angry*, *fearful* and *neutral*).

RESULTS

Trait emotional awareness and measures of affectivity

The LEAS was not correlated with STAI and BDI ($r = 0.05$ and $r = 0.09$, $P > 0.55$, two-tailed) or PANAS-N ($r = -0.01$, $P > 0.95$, two-tailed). However, the LEAS was significantly related to positive affect as assessed by the PANAS-P ($r = 0.38$, $P < 0.01$, two-tailed).

Behavioral performance in the fMRI experiment: shifts in implicit affect

A repeated measures analysis of variance (ANOVAs) on the implicit affect scores with prime (happy, neutral, angry and fearful) and valence (positive and negative) as within-subject factors was conducted to examine whether changes in implicit affect differ as a function of prime condition and valence. The main effects prime [$F(3,43) = 3.95$, $P < 0.05$] and valence [$F(1,45) = 31.6$, $P < 0.01$] and the interaction prime \times valence [$F(1,45) = 5.65$, $P < 0.01$] were significant. The mean changes for the different prime conditions are depicted in Figure 2.

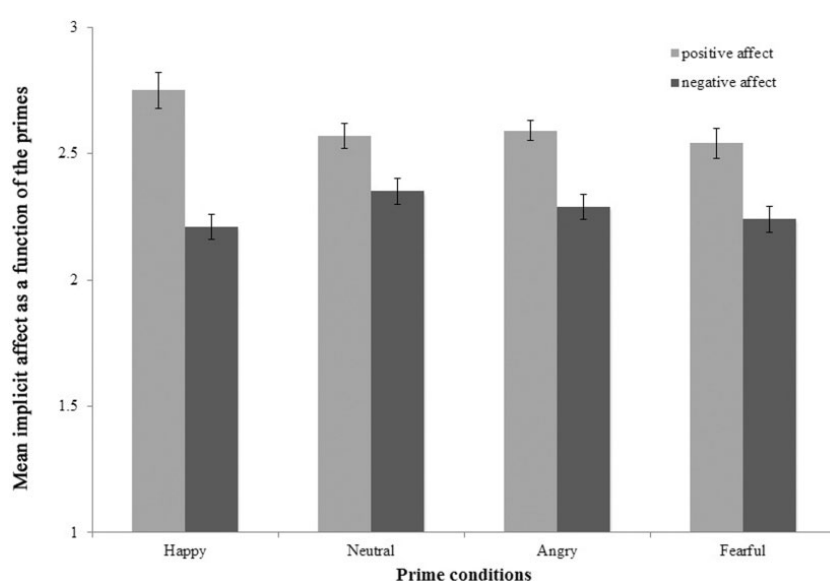


Fig. 2 Mean implicit positive and negative affect as a function of primes. Error bars represent standard error of the mean (SEM). The figure depicts mean implicit positive and negative affect following the presentation of masked happy, neutral, angry and fearful facial emotions.

Post hoc comparisons revealed significant differences in the increase of implicit positive affect in the happy vs neutral prime condition [$t(45) = 3.11$, $P < 0.01$]. There were no significant differences for the implicit negative affect. We correlated the difference score for the implicit positive affect in the happy against neutral prime condition with trait emotional awareness. The LEAS was positively correlated with this score even after controlling for trait positive affect ($r = 0.34$, $P < 0.05$, two-tailed; see Figure 3). Hence, participants with more emotional awareness showed more prime valence congruent shifts in implicit positive affect.

Detection task performance

All sensitivity values A' were at chance-level performance: for happy faces 0.51 ($se = 0.01$), for angry faces 0.49 ($se = 0.01$), for fearful faces 0.52 ($se = 0.01$) and for neutral faces 0.46 ($se = 0.03$). None of the sensitivity values were significantly different from 0.5 ($P > 0.05$), suggesting chance-level performance of study participants.

Neuroimaging results

Main effects of masked emotional faces on amygdala activation

Masked presentation of happy faces (compared with neutral faces) activated the bilateral amygdala (see Figure 4). No amygdala activation was revealed for masked angry and masked fearful faces.

Main effects of masked emotion faces on brain activation: whole-brain analysis

There was significantly more neural activation in response to masked happy compared with masked neutral faces in several regions of the brain (see Table 1 for details). Masked presentation of happy expression activated inferior and middle frontal, superior temporal, inferior and superior parietal areas and middle occipital regions as well as cerebellar and insular areas (see Table 1 for details). Masked happy faces activated also the basal ganglia and thalamus.

Masked fearful faces (compared with masked neutral faces) activated only areas in the right middle frontal gyrus [BA45, peak voxel xyz , 51, 20, 34 (MNI coordinates), cluster size: 12, Z -score = 4.03]. No brain activation was revealed for masked angry faces compared with masked neutral faces.

Correlations of trait emotional awareness with amygdala response to masked emotion faces controlling for trait positive affect (PANAS-P)

The voxel-wise ROI analysis of the amygdalae yielded significant positive correlations between LEAS and amygdala reactivity to masked happy faces (see Figure 5 for details). Importantly, there were no significant correlations in the opposite direction for happy faces. No positive (or negative) correlations between trait emotional awareness and amygdala response to masked fearful or masked angry faces were observed.

Correlations of trait emotional awareness with brain responses to masked happy faces controlling for trait positive affect (PANAS-P)

Trait emotional awareness was positively correlated with activation of the middle and medial frontal gyrus, the cingulate and lingual gyrus, precentral and postcentral regions in response to masked happy faces (see Table 2 and Figure 6 for details). Moreover, there were positive correlations between the LEAS and activation of the inferior parietal lobule, basal ganglia, thalamic and cerebellar regions in response to masked happy facial expression. There were no negative correlations between LEAS and brain response to masked happy faces.

Correlations of trait emotional awareness with brain responses to masked fearful and angry faces controlling for trait positive affect (PANAS-P)

Trait emotional awareness was positively correlated with response of the cingulate gyrus to masked fearful faces (BA31, peak voxel xyz , 24, -37, 34 (MNI coordinates), cluster size: 20, Z -score = 4.18; and BA24,

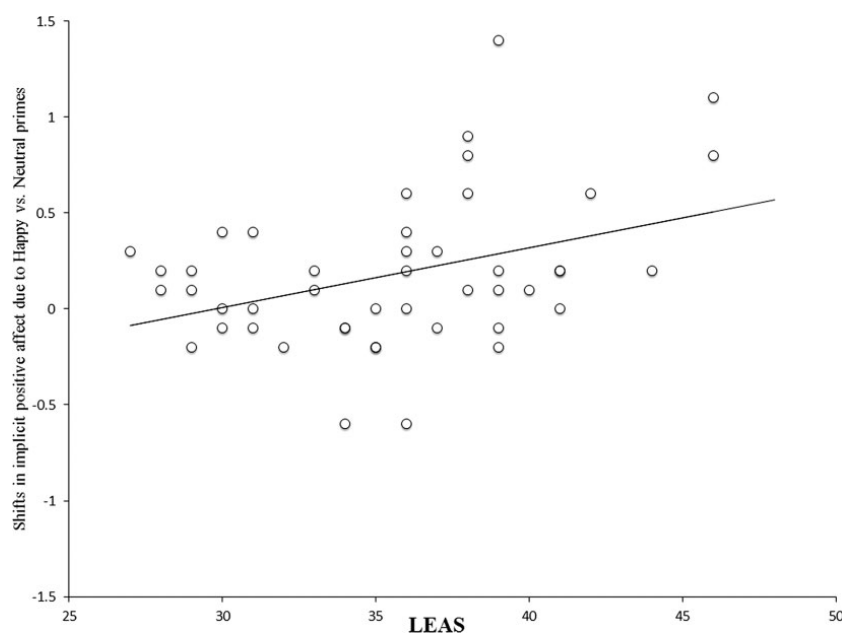


Fig. 3 Shifts in implicit positive affect due to masked happy as compared with masked neutral faces as a function of trait emotional awareness (LEAS) [$r = .34$, $P < .05$, two-tailed, controlled for positive affect (PANAS-P)]. The shifts were calculated by subtracting implicit positive affect scores for the neutral face condition from those of the happy face condition.

peak voxel xyz , 18, 5, 34, cluster size: 12, Z -score = 3.70). There were positive correlations between LEAS and activation of parietal areas (BA40, peak voxel xyz , 33, -40, 31, cluster size: 12, Z -score = 4.26; and BA40, peak voxel xyz , -51, -31, 25, cluster size: 13, Z -score = 4.04) and nucleus caudatus (extending to putamen) in response to angry facial expression (peak voxel xyz , -21, 14, 22, cluster size: 23, Z -score = 3.79). There were no negative correlations between trait emotional awareness and brain response to masked fearful or masked angry faces.

DISCUSSION

In this study, the relationship between trait emotional awareness and automatic brain reactivity to positive and negative facial emotions was

investigated in healthy adults. The results in the objective test of prime awareness indicate that subjects were unaware of the emotional primes presented during the fMRI experiment. Our hypotheses were confirmed in part. As expected, positive correlations were observed between trait emotional awareness and automatic reactivity in brain structures implicated in the processing of masked facial emotions and the development of implicit affect. However, these associations were found primarily for masked happy faces and, to a much lesser extent, for masked fearful and masked angry faces. Importantly, no negative correlations between trait emotional awareness and brain reactivity to masked facial emotions were found in our study. Thus, our data indicate that individuals with high emotional awareness show more activation in brain areas involved in emotion processing and simulation during the subliminal perception of happy facial emotion compared with individuals with low emotional awareness. These findings were independent of habitual positive affect.

The present fMRI data suggest that masked happy faces produced activation in many brain regions, which are known to be involved in the automatic processing of facial emotions (i.e. inferior and middle frontal, superior temporal and middle occipital gyri, insula, somatosensory cortex, cerebellar regions, basal ganglia, thalamus and amygdala; e.g. Killgore and Yurgelun-Todd, 2004; Rauch et al., 2007; Schutter et al., 2009; Suslow et al., 2009, 2010; Juruena et al., 2010). In contrast, masked fearful faces activated only the middle frontal gyrus, and masked angry faces showed no brain activation compared with masked neutral faces. This differential pattern of activation parallels the behavioral findings, which showed significant positive priming (based on happy facial expression) but no negative priming effects (based on fearful or angry facial expression). An explanation for the absence of amygdala response to fearful faces in our experiment could be the type of mask used. According to Kim et al. (2010), the amygdala response to fearful faces masked by pattern images substantially decreases compared with amygdala response to fearful faces masked by neutral faces. Diminished amygdala activation to fearful facial expression in the context of pattern masks might be caused by interactions of the amygdala with other neural systems. In our task, a sandwich-masking procedure was used consisting of randomly drawn letters. It is possible that the presentation of letter strings activated higher-order cortical structures, which inhibited the response of the amygdala. In sum, the present affective priming task produced activation and processing effects primarily for positive facial expression on a neural and behavioral level (see below for a detailed discussion of possible mood-congruent processing effects in our sample of healthy subjects). In the absence of a significant main effect of brain activation due to negative priming effects, an association with trait emotional awareness would be extremely difficult to detect.

Trait emotional awareness was found to be positively associated with activation in the primary somatosensory cortex, inferior parietal lobule, dorsal anterior cingulate gyrus, middle frontal and cerebellar areas, thalamus, putamen and amygdala in response to masked happy faces. This means, on the one hand, that high trait emotional awareness was associated with high responsivity to positive facial emotion in subcortical systems, which are relevant for the detection of biologically relevant stimuli. It is well-known that the amygdala is involved in the assessment of emotional significance (Davis and Whalen, 2001; Adolphs, 2010), the modulation of vigilance to enhance subsequent information processing throughout the brain and, like the pulvinar thalamus, the coordination of cortical networks during evaluation of visual stimuli (Pessoa and Adolphs, 2010). A close relationship between amygdala and striatal activity has been reported during the processing of reward relevant stimuli (Ousdal et al., 2012). The thalamus is part of a rapid subcortical path by which low-level visual information can reach the amygdala without conscious awareness (Phillips et al.,

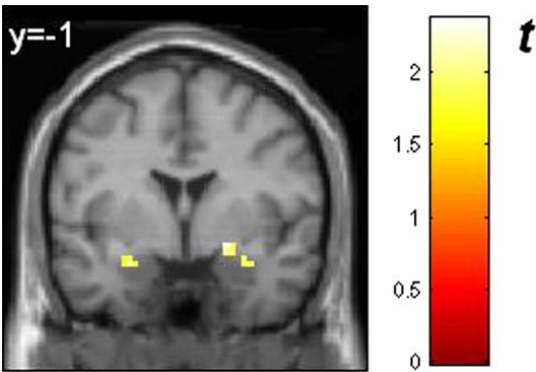


Fig. 4 Response of the amygdalae to masked happy faces compared with masked neutral faces (ROI analysis): left amygdala [peak voxel xyz , -27, -1, -20 (MNI coordinates), cluster size: 8, Z -score = 2.03] and right amygdala (peak voxel xyz , 21, 2, -14, cluster size: 8, Z -score = 2.37, and xyz , 36, 2, -23, cluster size: 7, Z -score = 2.06). All activations are significant at $P < 0.05$, corrected for search volume. The color bar (t value) indicates the strength of activation. BOLD responses are superimposed on MNI standard brain template. Reader's right is subjects' right.

Table 1 Brain regions showing significantly increased activation to masked happy faces as compared with masked neutral faces

Brain region	Hemisphere	Peak coordinates	Size	Z-score
Inferior frontal gyrus, BA47	L	-18 29 -14	17	3.82
Middle frontal gyrus, BA46	L	-45 41 4	31	4.05
Middle frontal gyrus, BA9	R	51 20 31	116	4.14
to middle frontal gyrus, BA46	R	48 23 19		3.67
Middle frontal gyrus, BA6	L	-30 14 52	10	3.56
Superior temporal gyrus, BA22	L	-51 -19 -8	30	4.13
Superior temporal gyrus, BA22	R	54 -46 7	129	3.87
to superior temporal gyrus, BA13	R	48 -49 13		3.84
Temporal lobe, subgyral, BA37	R	48 -43 -14	21	3.85
Inferior parietal lobule, BA40	L	-51 -52 46	16	3.67
Superior parietal lobule, BA7	L	-30 -64 52	17	3.37
Lingual gyrus, BA18	R	33 -70 -14	41	3.96
Middle occipital gyrus, BA19	R	24 -97 13	17	4.16
Occipital lobe, cuneus, BA19	R	27 -85 34	59	3.73
Insula, BA 13	L	-42 17 10	54	4.33
Putamen	R	24 23 -11	25	4.03
Caudate nucleus, caudate body	L	-9 8 7	38	3.86
to thalamus	L	-9 -7 10		3.48
Caudate nucleus, caudate body	R	12 5 7	28	3.68
Cerebellum, pyramis	L	-6 -73 -35	20	4.01
Cerebellum, pyramis	R	12 -73 -38	28	4.36

Hemisphere, peak voxel coordinates in MNI space, cluster extent and the associated Z-values are shown. The activations are significant at $P < .001$ (uncorrected), 10 voxel cluster threshold.

2004; Liddell *et al.*, 2005). The thalamic nuclei serve a variety of functions in the brain beyond relaying sensory information, which comprise the initiation and coordination of motor behavior (Schmahmann, 2003). Interestingly, amygdala, thalamus and basal ganglia have been reported to be activated during imitation of happy facial expression (Pohl *et al.*, 2013). In sum, according to our data, individuals with high levels of emotional awareness appear to be characterized by an enhanced reactivity in subcortical areas implicated in rapid stimulus evaluation and allocation of processing resources.

On the other hand, trait emotional awareness was also found to be positively related to response of several cortical areas such as the primary somatosensory cortex (SI) and inferior parietal lobule during the subliminal perception of happy faces. It has been shown repeatedly that the inferior parietal lobule is involved in the observation as well as in the imitation of emotional facial expression (Carr *et al.*, 2003; Hennenlotter *et al.*, 2005; van der Gaag *et al.*, 2007). The primary somatosensory cortex (SI) is known to be critically involved in the processes of emotional mimicry and simulation (Adolphs *et al.*, 2000). Primary somatosensory regions are implicated in simulating aspects of the body states associated with the viewed emotional state—including proprioceptive and somatovisceral sensations (Heberlein and Adolphs, 2007; Heberlein and Atkinson, 2009). According to the shared-substrates model of emotion recognition identification of other persons' emotional states is mediated by internally generated somatosensory representations that simulate how the other individual feels when showing a certain facial expression (Heberlein and Adolphs, 2007). Such vicarious responding has also been discussed in the context of empathic responses (Preston and de Waal, 2002). Interestingly, previous psychological research has reported that trait emotional awareness is related to enhanced empathy (Ciarrochi *et al.*, 2003; Igarashi *et al.*, 2011). Lane (2008) has pointed out that the somatosensory and parietal cortex could participate in the experience of the somatic sensations associated with implicit responses.

Finally, trait emotional awareness was correlated with activation in areas of the ACC and cerebellum in response to masked happy faces. The ACC is an integral part of the limbic system and participates in emotion formation and processing. Specifically, dorsal regions of the ACC are involved in the appraisal of emotion (Etkin *et al.*, 2011). The cerebellum is incorporated into distributed neural circuits subserving emotion perception and social interaction (Schmahmann, 2010). Increased cerebellar responses to masked happy faces could subserve processes of increased implicit attention for positive social stimuli

(Schutter *et al.*, 2009). All in all, the present neuroimaging data show that trait emotional awareness is positively associated with activation in brain areas responsible for rapid stimulus evaluation and emotion simulation during the subliminal perception of happy facial expression. These findings are in line with the idea that emotional awareness is characterized by an enhanced affective resonance to others at an automatic processing level (Ciarrochi *et al.*, 2003; Igarashi *et al.*, 2011).

It is interesting to note in this context that previous studies have demonstrated a positive relationship of level of emotional awareness with verbal and non-verbal recognition of facial emotions (Lane *et al.*, 1996, 2000b). In the light of the present results, it appears possible that more spontaneous activation in brain areas implicated in emotion simulation could have been a factor promoting the identification of emotion from facial expression in high compared with low trait emotional awareness.

Our behavioral results partially confirm the hypothesis that the LEAS is positively related to shifts in implicit affect owing to masked facial emotion. High trait emotional awareness was associated with stronger shifts in implicit positive affect caused by happy facial expression. Importantly, in our experiment, presentation of masked happy faces induced significant increases in implicit positive affect compared with the presentation of neutral faces, but there was no indication that masked negative (i.e. angry and fearful) faces elicited implicit negative affect. The present data suggest that high emotional awareness is characterized by an enhanced resonance to others' positive affects at an automatic processing level. Affective resonance refers to a person's tendency to experience the same affect in response to viewing a display of that affect by another person. Individuals with high levels of emotional awareness appear to develop stronger implicit positive affects in response to others' brief facial expressions compared with those with low levels of emotional awareness. These results of an enhanced affective resonance are consistent with those of previous studies showing that individuals with high emotional awareness allocate involuntarily more attention to emotional stimuli (Suslow *et al.*, 2001) and react with more physiological arousal to them (Lane *et al.*, 2000a; McRae *et al.*, 2008). Thus, there is evidence that functioning at high levels of emotional awareness (i.e. levels of explicit processes of emotional experience) goes along with pronounced implicit affects and reactions (bodily sensations and automatic attention allocation). This does not

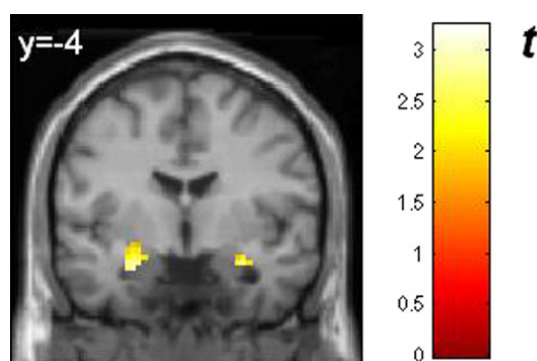


Fig. 5 Regions within the amygdalae showing positive correlations between response to masked happy faces and trait emotional awareness (LEAS) controlling for trait positive affect (PANAS-P): left amygdala (peak voxel xyz, -27, -7, -17 (MNI coordinates), cluster size: 25, Z-score = 2.95) and right amygdala (peak voxel xyz, 30, -1, -23, cluster size: 20, Z-score = 3.05). Activations are significant at $P < 0.005$, corrected for search volume. The color bar (t value) indicates the strength of correlation. BOLD are superimposed on MNI standard brain template. Reader's right is subjects' right.

Table 2 Brain regions showing significantly increased activation to masked happy faces as a function of trait emotional awareness (LEAS) controlling for trait positive affect (PANAS-P)

Brain region	Hemisphere	Peak coordinates	Size	Z-score
Medial frontal gyrus, BA32	L	-15 8 49	16	4.18
Middle frontal gyrus, BA46	R	36 35 13	19	3.63
Cingulate Gyrus, BA24	L	-18 -16 40	56	4.54
to precentral gyrus, BA4	L	-30 -19 46		3.59
to postcentral gyrus, BA3	L	-39 -25 52		3.38
Postcentral gyrus, BA2	R	33 -22 34	43	4.08
Postcentral gyrus, BA3	L	-24 -40 52	13	3.72
Inferior parietal lobule, BA40	L	-51 -31 25	29	3.68
to postcentral gyrus, BA2	L	-39 -28 31		3.58
Occipital lobe, lingual gyrus	L	-12 -61 -8	15	3.64
Clastrum	L	-27 -22 19	107	4.68
to thalamus	L	-18 -19 4		4.05
Putamen	R	24 -10 13	10	3.73
Cerebellum, culmen	R	12 -55 -14	19	3.63

Hemisphere, peak voxel coordinates in MNI space, cluster extent and the associated Z-values are shown. The activations are significant at $P < .001$ (uncorrected), 10 voxel cluster threshold.

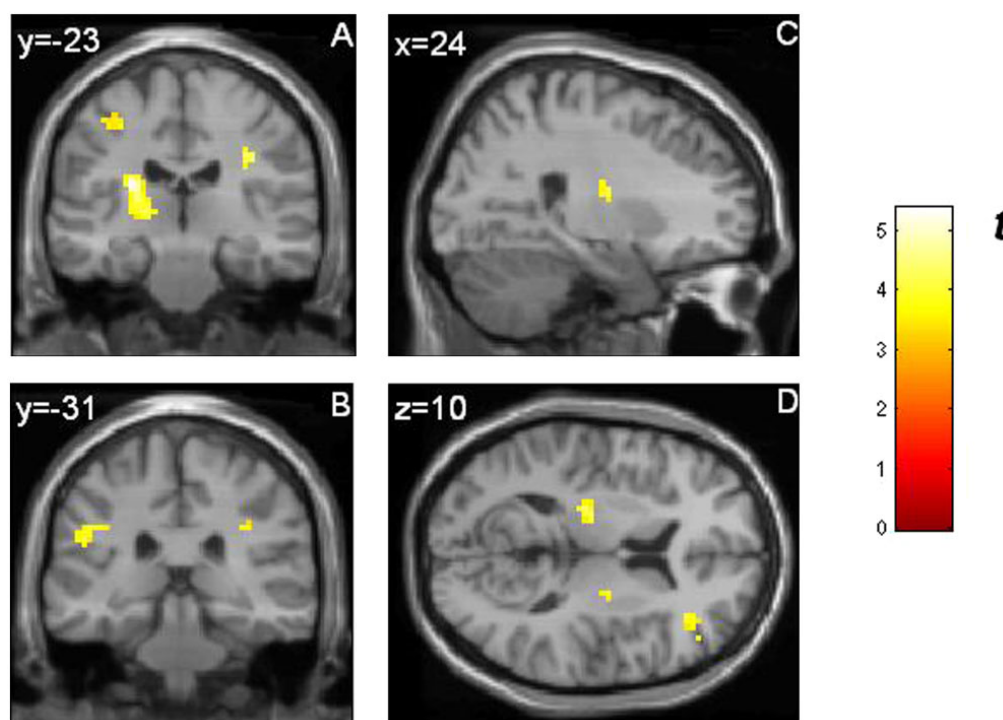


Fig. 6 Brain regions showing positive correlations between response to masked happy faces and trait emotional awareness (LEAS) controlling for trait positive affect (PANAS-P): (A) coronal view: activation in the left postcentral gyrus (BA3; extending to precentral and cingulate gyrus; peak voxel xyz, $-39, -25, 52$ (MNI coordinates), cluster size: 56, Z-score = 3.38), left thalamus (extending to claustrum; peak voxel xyz, $-18, -19, 4$, cluster size: 107, Z-score = 4.05) and right postcentral gyrus (BA2; peak voxel xyz, $33, -22, 34$, cluster size: 43, Z-score = 4.08); (B) coronal view: activation in the left inferior parietal lobule (BA40, peak voxel xyz, $-51, -31, 25$, cluster size: 29, Z-score = 3.68) and right postcentral gyrus (BA2; peak voxel xyz, $33, -22, 34$, cluster size: 43, Z-score = 4.08); (C) sagittal view: activation in the right putamen (peak voxel xyz, $24, -10, 13$, cluster size: 10, Z-score = 3.73); (D) axial view: activation in the left thalamus (extending to claustrum; peak voxel xyz, $-18, -19, 4$, cluster size: 107, Z-score = 4.05), right putamen (peak voxel xyz, $24, -10, 13$, cluster size: 10, Z-score = 3.73) and right middle frontal gyrus (BA46, peak voxel xyz, $36, 35, 13$, cluster size: 19, Z-score = 3.63). All activations are significant at $P < 0.001$ (uncorrected). The color bar (t value) indicates the strength of correlation. BOLD responses are superimposed on MNI standard brain template. Reader's right is subjects' right.

contradict assumptions of the levels of emotional awareness theory according to which functioning at a high level can modify but does not eliminate the function of previous levels (Lane, 2008).

It is possible that the positive mood state of our healthy study participants induced mood-congruent response biases favoring the processing of happy facial expression. This might have facilitated the detection of associations between emotional awareness and automatic brain response to happy facial expression in our sample. In our study, we found evidence for positive priming owing to masked happy faces (i.e. there was a positive prime valence congruent shift in implicit affect caused by happy faces compared with neutral faces) but our results did not provide any evidence for negative priming effects elicited by masked angry or fearful faces (i.e. no negative prime valence congruent shifts in implicit affect were found for angry or fearful faces compared with neutral faces). The results from the first studies examining shifts in affective or liking evaluations owing to masked facial emotions on the basis of the affective priming paradigm (Murphy and Zajonc, 1993; Murphy *et al.*, 1995) suggested comparably pronounced effects of positive and negative facial expression on evaluations. Compared with neutral expression, angry facial expression led to more negative evaluations of subsequently presented stimuli, whereas happy facial expression elicited more positive evaluations of subsequently presented stimuli. However, subsequent behavioral studies on affective priming in which samples of healthy adults were examined frequently failed to find negative priming effects. There are four studies using sad and happy faces as emotional primes in which (valence congruent) affective priming effects were only observed for happy but not for sad faces (Suslow *et al.*, 2003; Wong and Root, 2003; Dannlowski and Suslow,

2006; Donges *et al.*, 2012). In addition, results from three other studies administering happy and angry faces as emotional primes indicate (valence congruent) affective priming only for happy but not for angry faces (Rotteveel *et al.*, 2001, experiment 1; Dannlowski *et al.*, 2007; Paul *et al.*, 2012). Finally, in the study of Almeida *et al.* (2013), affective priming for happy faces was stronger than that for angry faces. In all of the aforementioned affective priming studies, participants were unaware of the primes as controlled by measures of subjective or objective awareness.

It can be concluded that our findings of significant priming based on happy faces but no priming based on negative faces are consistent with results from many previous investigations examining automatic influences of masked facial emotion on affective or evaluative processes. The healthy participants of our study tended to show mood-congruent priming effects. The selective susceptibility or responsiveness to positive social information at an automatic processing level as found in this study is similar to observations made in research on attention in depressed and normal individuals. According to these findings, healthy (as opposed to depressed) subjects are characterized by attentional biases favoring positive stimuli (Gotlib *et al.*, 1988) and avoiding negative stimuli (McCabe and Gotlib, 1995; Karparova *et al.*, 2007). This pattern of attention allocation has been termed positive or protective bias. There is evidence that protective biases away from negative information can operate at an early stage of information processing in healthy subjects (Leyman *et al.*, 2009). It has also been shown in electrophysiological studies that normal individuals manifest an early response bias for positive information (Deldin *et al.*, 2001). As noted above, the absence of a negative priming effect might explain the

failure to detect associations between emotional awareness and negative evaluative shifts in our sample.

To further clarify the issue of a relationship between emotional awareness and negative affective priming, it appears advisable to include clinical subjects such as depressed, anxious or schizophrenia patients in future studies. These patients have shown (mood-congruent) negative affective priming effects in previous studies (Suslow *et al.*, 2003, 2013; Dannlowski *et al.*, 2006). It would be interesting to examine whether patients with higher trait emotional awareness manifest stronger negative priming. We assume that trait emotional awareness can basically affect the processing of negative as well as positive stimuli but that the detection of relationships may depend on the mood characteristics and processing biases of study participants.

These data suggest that the extent of reflective awareness of feelings may also derive from the extent and intensity of implicit affective reactions. High responsiveness of limbic and somatosensory areas to emotional signals of low intensity in everyday life could make the recognition of subtle emotions less difficult. People who develop automatically stronger bodily feelings to emotional stimuli might become more easily aware of these spontaneous affective reactions and make them more frequently the objects of conscious reflection, resulting in reports reflecting more complex processing of emotional information. Less detailed processing and somatosensory representation of facial emotional expressions could contribute to a decreased ability to draw inferences about the emotional and motivational significance of fundamental interpersonal signals. Reduced activation in limbic areas when attempting to feel other people's feelings or retrieving their own emotional episodes has been reported previously for people with decreased emotional awareness (see Kano and Fukudo, 2013, for an overview). Low spontaneous cerebral responsivity to external emotional triggers as found in our study coincides with the empirical impression of clinicians that people with decreased affect awareness look unaffected and emotionally dull (Moriguchi and Komaki, 2013).

Previous research addressing the neural correlates of trait emotional awareness has focused exclusively on explicit emotion processing. Lane *et al.* (1998) and McRae *et al.* (2008) reported more activation primarily of the ACC during film- or recall-induced emotion and during viewing of emotional pictures in individuals with higher emotional awareness [see also Frewen *et al.*'s study (2008) in which similar results have been obtained in the control group]. Our data on early stages of emotion processing complement the previous findings by showing that subjects with high levels of emotional awareness activate brain regions implicated in evaluation and affective resonance more strongly during automatic emotion perception compared with those with low levels of emotional awareness. These data suggest that more emotionally aware individuals could have more neurally elaborated emotional reactions and representations even before they are consciously aware of the emotions. This could mean that the interoceptive information that forms the basis for reporting on experience is possibly more detailed or elaborated even before it is put into words in people who are more emotionally aware. Quirin and Lane (2012) have argued that the reflective construction of emotional experience requires the integration of implicit and explicit emotional processes. It appears that greater awareness does not just involve better ability to put emotions into words or appreciate complexity in one's own experience and that of others; it seems to involve a more elaborated type of bottom-up emotion processing and an enhanced automatic affective resonance to others that creates the possibility for enhanced emotional awareness. This is consistent with emotional awareness theory (Lane and Schwartz, 1987; Lane, 2008), which states that more detailed schemata for processing emotional stimuli lead to more detailed emotional information processing independent of and preceding the reporting function itself.

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Chapter 4

Discussion

This chapter summarizes the results of two original research articles and integrates them into a multi-method approach of assessing alexithymia and emotional awareness. Further, the model and the dissertation in general are discussed. Finally, the chapter is closed with a conclusion.

4.1 Summary of the results

Study 1 evaluated interrelationships and psychometric properties of different methods of alexithymia and emotional awareness measurement in a German sample of university students. Further the number of factors that underlie these two measures of alexithymia (i.e. TAS-20 and TSIA) and one of emotional awareness (i.e. LEAS) was investigated. Based on the results from a previous study (Lumley et al., 2005) it was hypothesized that a three-factor structure may best represent the data. Results from exploratory factor analysis (EFA) based on all measures supported a three factorial solution (i.e. explicit self, explicit other and implicit self). Therefore, the present results corroborate the hypothesis that all three measures will be reflected by three different factors: explicit-self, explicit-other, and implicit-self.

Study 2 is the first to investigate automatic brain reactivity to emotional stimuli (i.e. positive and negative facial expressions) as a function of the personality traits emotional awareness and alexithymia. Based on previous research (Lane et al., 1996; 2000; Suslow et al., 2001) it was hypothesized that trait emotional awareness would be a better predictor of automatic emotion processing at a neural and behavioral level than alexithymia. Concerning the behavioral data, the mean differences in implicit positive affect were positively associated with the LEAS scores. These findings were independent of positive affect (i.e. PANAS). That is, individuals with high emotional awareness showed stronger prime valence congruent shifts in implicit positive affect than those low in emotional awareness. High emotional awareness appears to be associated with a perceptual sensitivity for happy facial expression of low intensity and high affective reactivity. Vice versa, low emotional awareness seems related to difficulties in the automatic read-out of emotional information and implicit affective reactivity. Importantly, no such relations were found for measures of alexithymia. Alexithymia, as measured with the interview, tended to be related to prolonged decision latencies during the processing of happy and

angry facial expressions. That is, individuals with increased alexithymia need more time to make evaluative judgments. Interestingly, the objective measures LEAS and TSIA (but not the self-report instrument TAS-20) were predictors of behavioral performance⁸. This is in line with observations from personality research indicating that objective tests predict more spontaneous behaviors whereas self-report measures predict more controlled behaviors (Asendorpf et al., 2002; Strack and Deutsch, 2004). Thus, we found evidence for the hypotheses that high alexithymia and low emotional awareness are related to altered behavioral performance in the affective priming task and that trait emotional awareness is a better predictor of automatic emotion processing than alexithymia at a behavioral level. The revealed behavioral results are consistent with those of a previous study (Suslow et al., 2001) suggesting that low emotional awareness is associated with a reduced processing engagement towards emotional stimuli at an automatic processing level. Regarding the neuroimaging data, low trait emotional awareness and high alexithymia were associated with reduced activation in several cortical and subcortical areas including amygdala, thalamus, primary somatosensory cortex, inferior frontal gyrus, superior temporal gyrus, and middle occipital areas. Low trait emotional awareness was additionally related to decreased activation in insula and fusiform gyrus. However, the effects were stronger for positive than for negative stimuli. Therefore, these findings could imply less spontaneous attention to positive emotions in daily life resulting in poor awareness and therefore less positive affect in individuals with low emotional awareness (i.e. high alexithymia). Therefore, the frequently observed negative affectivity in alexithymia may in part be due to the inability of alexithymic individuals to up-regulate positive affect at an implicit level. This finding is in line with recent research (Hesse et al., 2013) showing impairments in the decoding of explicit positive affect in high alexithymia individuals. Moreover, these findings support the hypotheses that low trait emotional awareness and high alexithymia are related to decreased reactivity in brain structures implicated in the automatic emotion processing and that emotional awareness is a better predictor of brain reactivity of automatic emotion processing at neural level than alexithymia.

4.2 Integration of the results

The present work is the first to use multi-method approach of alexithymia by applying two measures of alexithymia and one measure of emotional awareness. In the tested factor model three factors: direct self (TAS-20), direct other (TSIA), and indirect self (LEAS) were extracted. This is in line with previous research on alexithymia and emotional abilities (Lumley et al., 2005; Meganck et al., 2011). Further, the neurobiological correlates of alexithymia and emotional awareness have been explored. In line with previous research (Kugel et al., 2008; Eichmann et al., 2008; Reker et al., 2010; Duan et al., 2010), it has been found that high alexithymia is associated with a reduced processing engagement towards emotional stimuli at an automatic processing level. Further, it was reported that emotional awareness is a better predictor of automatic emotion processing than alexithymia. Therefore, the present

⁸See table 1 and figure 1 of the supplementary materials for study 2.

dissertation not only replicate the multi-method approach of alexithymia proposed by Lumley et al. (2005), but extend this model by suggesting another factor (i.e. implicit other) in the face of brain reactivity to emotional stimuli. Future research might benefit from the use of more objective measures of alexithymia such as performance tasks and neurobiological parameter.

4.3 Limitations and future research

In the present study no significant changes in implicit negative affect (i.e. affective priming effect) were found. Therefore, to further clarify the issue of the relationship between emotional awareness, alexithymia and emotion processing at automatic level, it appears advisable to include clinical subjects such as depressed, anxious or schizophrenia patients in future studies. These patients have shown (mood-congruent) negative affective priming effects in previous studies (Suslow et al., 2003, 2013; Dannlowski et al., 2006). It would be interesting to examine whether patients with higher trait emotional awareness manifest stronger negative priming. It is assumed that trait emotional awareness can basically affect the processing of negative as well as positive stimuli but that the detection of relationships may depend on the mood characteristics and processing biases of study participants.

4.4 Conclusions

To conclude, the present work found evidence that various measures of alexithymia and emotional awareness using different methodological approaches are only moderately associated. In our three factor model, direct self (TAS-20), direct other (TSIA), and indirect self (LEAS) measures were differentiated. These measurement instruments may capture different aspects of emotion recognition or emotional awareness but it appears that at least to some extent variation between measures can be explained by differences among assessment methods. The administered measures of alexithymia and emotional awareness seem not to be primarily related to a unitary construct but differ as a function of the source providing the information (self vs. other) and whether the measure is indirect or direct. The findings also suggest that trait emotional awareness is a better predictor of emotions processing at automatic level. Moreover, as only trait emotional awareness appears to uncover deficits in the regulation of positive affect at behavioral and neural level, future studies could benefit from including LEAS in order to gain more understanding of the regulation of positive and negative affect in alexithymia.

Chapter 5

Zusammenfassung der Arbeit

Dissertation zur Erlangung des akademischen Grades

Dr. rer. med.

Relations between emotional awareness and alexithymia measures:
Behavioral and neurobiological evidence

eingereicht von:

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geboren am 14.09.1983 in Kardzhali, Bulgarien

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Introduction

Understanding emotion and its regulation is arguably the main challenge of the psychosomatic medicine for 21st century. Unveiling the phenomenological, physiological and neurobiological correlates of emotion will necessarily advance our understanding of the relationship between emotion and bodily processes. Especially, in psychosomatic patients the relation between emotion and bodily processes seems to be disentangled (Lane,2008;Waller & Scheidt,2004). To study this relation psychosomatic research has predominately focussed on constructs such as alexithymia (Taylor et al.,1996), suppression (Scheier & Bridges,1995), type C personality (Temoshok et al.,2008) and type D personality (Denollet et al.,2006). All these constructs have a common denominator involving negative emotions which are not consciously experi-

enced and therefore regulated in a way leading to somatic complaints. Moreover all these constructs focus on deficits in the inability to experience and regulate emotions and are mainly assessed by self-report measures. However, the use of self-report in the context of alexithymia and emotional awareness assumes (as basic prerequisite) valid judgments about one's ability to monitor and report on internal emotional states (Lane et al.,1996,2000;Gündel et al.,2000;Suslow et al.,2001). Especially for high degrees of alexithymia this assumption might be violated because individuals may be unable to accurately rate their deficits in emotional awareness (Lane et al.,2000). Therefore, in order to understand emotion and its regulation in the case of alexithymia, first a valid measurement approach relying not only on self-report but also on more objective measures such as interviews and performance tasks are needed. Second, after a valid measurement approach has been identified and evaluated, the neurobiological correlates of alexithymia and emotional awareness have to be understood. Research addressing the neurobiological correlates of alexithymia has predominantly focused on controlled or explicit processing of emotional information. Several regions have been highlighted as altered in alexithymia, especially the anterior cingulate cortex (Lane et al.,1997), the insula (Bird et al.,2010;Kano et al.,2003;Ihme et al.,2013), and the fusiform gyrus (Karlsson et al.,2008). Thus, research on controlled emotion processing suggests impairments in several cortical areas as a function of alexithymia. However, according to Zajonc's (1980) affective primacy hypothesis, initial responses to emotional stimuli are automatic and do not necessarily require conscious awareness (Critchley et al.,2000;Morris et al.,1998;Suslow et al.,2013;Whalen et al.,1998;Winkielman et al.,2007). While there are several studies on controlled emotion processing in alexithymia, only a few neuroimaging studies have addressed the automatic brain reactivity to emotional information as a function of alexithymia. So far several structures have been highlighted as altered in alexithymia, especially the amygdala, fusiform gyrus, insula, superior temporal gyrus, middle occipital, temporal, and parahippocampal gyrus (Kugel et al.,2008;Eichmann et al.,2008;Reker et al.,2010;Duan et al.,2010). However, all of the above-mentioned neuroimaging studies on automatic emotion processing used self-report to measure alexithymia. To date, no imaging or behavioral study has examined automatic emotion processing as a function of alexithymia or emotional awareness as measured with interview or performance task.

Original research articles

In order to test a multi-method approach of alexithymia and emotional awareness and its behavioral and neurobiological correlates, one psychometric and one imaging (i.e. fMRI) studies have been conducted. These are compiled into the following two original articles:

Study 1:

Lichev, V., Rufer, M., Rosenberg, N., Ihme, K., Grabe, H., Kugel, H., Donges, U., Kersting, A., & Suslow, T. (2014). Assessing alexithymia and emotional awareness: Relations between measures in a German non-clinical sample. *Comprehensive Psychiatry*, 55(4), 952–959.

Study 2:

Lichev, V., Sacher, J., Ihme, K., Rosenberg, N., Quirin, M., Lepsien, J., Pampel, A., Michael, R., Grabe, H., Kugel, H., Kersting, A., Villringer, A., Lane, R., & Suslow, T. (2014). Automatic emotion processing as a function of trait emotional awareness: An fMRI study. *Social Cognitive and Affective Neuroscience*. In Press.

Study 1:

In study 1 the psychometric properties and relations between two different methods of measuring alexithymia and one measure of emotional awareness were evaluated. Further based on the results from a previous study (Lumley et al., 2005) it was hypothesized that a three-factor structure may best represent the data. The 20-Item Toronto Alexithymia Scale (TAS-20), the Toronto Structured Interview for Alexithymia (TSIA), and the Levels of Emotional Awareness Scale (LEAS), which is a performance-based measure of emotional awareness, were administered to 84 (39 women; mean age = 23.8 years, $SD = 2.8$) university students. None of the participants suffered from current mental disorders or had any lifetime history of psychiatric condition according to the criteria of DSM-IV, as assessed with the Structured Clinical Interview for DSM-IV Axis I disorders. Two interviewers conducted the TSIA ratings. All interviewers were trained in the administration and scoring of the interview by one of the translators (MR) of the German version of the TSIA. All interviews were video recorded for the assessment of inter-rater reliability. Both internal reliability and inter-rater reliability for the TSIA were acceptable. Results from exploratory factor analysis (EFA) based on all measures supported a three factorial solution previously obtained in an American sample using multiple methods of alexithymia and emotional ability measurement. In our three factor model direct self (TAS-20), direct other (TSIA), and indirect self (LEAS) measures were differentiated. Moreover the convergent validity of the TSIA was supported by a significant correlation with the LEAS.

Study 2:

Study 2 addressed automatic brain reactivity to emotional stimuli as a function of traits alexithymia and emotional awareness. The 20-item Toronto Alexithymia Scale (TAS-20) and the Toronto Structured Interview for Alexithymia (TSIA) were applied as self-report and interview measures of alexithymia. To assess emotional awareness the Levels of Emotional Awareness Scale (LEAS) was administered. During scanning, masked happy, angry, fearful and neutral facial expressions were presented to 46 healthy subjects (23 women; mean age = 23.5 years, $SD = 2.7$), who had to rate the fit between artificial and emotional words. The rating procedure allowed assessment of shifts in implicit affectivity due to emotional faces. To evaluate the success of the masking procedure, a forced-choice detection task was administered outside the scanner after the fMRI experiment. The detection task had the same presentation conditions and the same stimuli as the fMRI experiment. The results in the objective test of prime awareness indicate that subjects were unaware of the emotional primes presented during the fMRI experiment. As expected traits alexithymia and emotional awareness were related to altered automatic reactivity

in brain structures implicated in the processing of masked facial emotions and the development of implicit affect. Traits alexithymia and emotional awareness were associated with altered activation especially in the primary somatosensory cortex, inferior parietal lobule, anterior cingulate gyrus, middle frontal and cerebellar areas, thalamus, putamen and amygdala in response to masked faces. Low trait emotional awareness was additionally related to decreased activation in insula and fusiform gyrus. However, these associations were found primarily for masked happy faces and to a much lesser extent, for masked fearful and masked angry faces. Importantly, no negative correlations between trait alexithymia or emotional awareness and brain reactivity to masked facial emotions were found in our study. Thus, our data indicate that individuals with high alexithymia or low emotional awareness show less activation in brain areas involved in emotion processing and simulation during the subliminal perception of happy facial emotion compared with individuals with high emotional awareness. These findings were independent of habitual positive affect. Regarding the behavioral data, trait emotional awareness correlated positively with shifts in implicit affect caused by masked happy faces. In other words participants with more emotional awareness showed more prime valence congruent shifts in implicit positive affect. Moreover, trait alexithymia as measured with TSIA was related to prolonged decision latencies during the processing of happy and angry facial expressions. That is, individuals with increased alexithymia need more time to make evaluative judgments. According to our findings, people with high alexithymia and low emotional awareness show weaker affective reactivity and less activation in brain areas involved in emotion processing and simulation during the perception of masked happy facial expression than people with low alexithymia and high emotional awareness. In sum, trait emotional awareness was a better predictor of neural and behavioral responses than alexithymia.

General Discussion

Study 1 evaluated interrelationships and psychometric properties of different methods of alexithymia and emotional awareness measurement in a German sample of university students. Further the number of factors that underlie these two measures of alexithymia (i.e. TAS-20 and TSIA) and one of emotional awareness (i.e. LEAS) was investigated. Based on the results from a previous study (Lumley et al., 2005) it was hypothesized that a three-factor structure may best represent the data. Results from exploratory factor analysis (EFA) based on all measures supported a three factorial solution (i.e. explicit self, explicit other and implicit self). Therefore, the present results corroborate this hypothesis. Study 2 is the first to investigate automatic brain reactivity to emotional stimuli (i.e. positive and negative facial expressions) as a function of the personality traits alexithymia and emotional awareness. Based on previous research (Kano et al., 2003; Duan et al., 2010; Reker et al., 2010) it was hypothesized that both traits are related to altered brain reactivity of masked facial emotions. Moreover, based on previous research (Lane et al., 1996; Suslow et al., 2001) it was hypothesized that trait emotional awareness is a better predictor of automatic emotion processing at a neural and behavioral level. Concerning the behavioral data, the mean differences in implicit positive affect were positively associated with the LEAS scores. These findings were independent of

habitual positive affect (i.e. PANAS). That is, individuals with high emotional awareness showed stronger prime valence congruent shifts in implicit positive affect than those low in emotional awareness. High emotional awareness appears to be associated with a perceptual sensitivity for happy facial expression of low intensity and high affective reactivity. Vice versa, low emotional awareness seems related to difficulties in the automatic read-out of emotional information and implicit affective reactivity. No such correlations for alexithymia were observed. However, trait alexithymia as measured with TSIA predicted prolonged decision latencies during the processing of positive and negative emotions. Ergo the more objective measures were better predictors of behavioral performance in the affective priming task. This is in line with observations from personality research indicating that objective tests predict more spontaneous behaviors such as snap decisions in the affective priming task whereas self-report measures predict more controlled behaviors (Asendorpf et al., 2002; Egloff & Schmukle, 2002; Strack & Deutsch, 2004; Schmukle & Egloff, 2005). Therefore, we found evidence for the hypotheses that low emotional awareness and high alexithymia is related to altered behavioral performance in the affective priming task. The results support also the hypothesis that emotional awareness is a better predictor of automatic emotion processing at behavioral level than alexithymia. Regarding the neuroimaging data, low trait emotional awareness and high alexithymia were associated with reduced activation in several cortical and subcortical areas. Accordingly the hypothesis that low emotional awareness and high alexithymia are related to altered brain reactivity is confirmed. Moreover, the hypothesis that emotional awareness is a better predictor of brain reactivity of automatic emotion processing than alexithymia is also partly confirmed⁹.

Conclusion

In conclusion, the present work found evidence that various measures of alexithymia and emotional awareness using different methodological approaches are only moderately associated. In our three factor model, direct self (TAS-20), direct other (TSIA), and indirect self (LEAS) measures were differentiated. These measurement instruments may capture different aspects of emotion recognition or emotional awareness but it appears that at least to some extent variation between measures can be explained by differences among assessment methods. The findings suggest also that trait emotional awareness is a better predictor of emotions processing at automatic level than alexithymia. Moreover, trait emotional awareness appears to uncover deficits in the regulation of positive affect at behavioral and neural level. These findings could imply less spontaneous attention to positive emotions in daily life resulting in poor awareness and therefore less positive affect in individuals with low emotional awareness. Therefore, the frequently observed negative affectivity in alexithymia may in part be due to the inability of alexithymic individuals to up-regulate positive affect at an implicit level. Future studies could benefit from including LEAS in order to gain more understanding of the regulation of positive and negative emotions in alexithymia.

⁹See also the supplementary materials for study 2.

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Appendix

Curriculum vitae

Demographische Angaben

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Ausbildung

12/10–11/13	Doktorand, Medizinische Fakultät, Universität Leipzig
10/04–10/10	Diplom in Psychologie, Universität Halle
11/03–06/04	Sprachkurs, Advanced Studies of Languages, München
04/03–10/03	Austauschsemester, Martin-Luther Universität Halle-Wittenberg
10/01–03/03	Studium auf Lehramt, Plovdiver Universität Paisii Hilendarski
09/93–05/01	Abitur, Otez-Paisii-Gymnasium, Kardzhali

Forschungsarbeit

12/10–11/13	Wissenschaftlicher Mitarbeiter, Medizinische Fakultät, Universität Leipzig
12/09–01/10	Wissenschaftliche Hilfskraft, Abteilung für Entwicklungspsychologie, Universität Halle
08/09–10/09	Wissenschaftliche Hilfskraft, Klinik für Diagnostische Radiologie, Universitätsklinikum Halle
04/08–08/09	Wissenschaftliche Hilfskraft, Abteilung für Differentielle Psychologie und psychologische Diagnostik, Universität Halle
01/07–12/07	Wissenschaftliche Hilfskraft, Abteilung für Allgemeine Psychologie, Universität Halle
11/05–05/06	Wissenschaftliche Hilfskraft, Abteilung für Differentielle Psychologie und psychologische Diagnostik, Universität Halle
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Sprachkenntnisse

bulgarisch	Muttersprache
deutsch	Sehr gut
englisch	Sehr gut
russisch	Sehr gut

15.12.2014

Datum

B. Anceff

Unterschrift

List of publications

Peer-reviewed

1. Lichev, V., Rufer, M., Rosenberg, N., Ihme, K., Grabe, H., Kugel, H., Donges, U., Kersting, A., & Suslow, T. (2014). Assessing alexithymia and emotional awareness: Relations between measures in a German non-clinical sample. *Comprehensive Psychiatry*, 55(4), 952–959.
2. Lichev, V., Sacher, J., Ihme, K., Rosenberg, N., Quirin, M., Lepsien, J., Pampel, A., Michael, R., Grabe, H., Kugel, H., Kersting, A., Villringer, A., Lane, R., & Suslow, T. (2014). Automatic emotion processing as a function of trait emotional awareness: An fMRI study. *Social Cognitive and Affective Neuroscience*. In Press.
3. Ihme, K., Sacher, J., Lichev, V., Rosenberg, N., Kugel, H., Rufer, M., Grabe, H., Pampel, A., Lepsien, J., Kersting, A., Villringer, A., & Suslow, T. (2014). Alexithymia and the labeling of facial emotions: Response slowing and increased motor and somatosensory processing. *BMC Neuroscience*, 15(40) 1–10.
4. Ihme, K., Sacher, J., Lichev, V., Rosenberg, N., Kugel, H., Rufer, M., Grabe, H., Pampel, A., Lepsien, J., Kersting, A., Villringer, A., Lane, R., & Suslow, T. (2014). Alexithymic features and the labeling of brief emotional facial expressions – an fMRI study. *Neuropsychologia*, 64: 289–299.
5. Ihme, K., Dannlowski, U., Lichev, V., Stuhrmann, A., Grotegerd, D., Rosenberg, N., Kugel, H., Heindel, W., Arolt, V., Kersting, A., & Suslow, T. (2013). Alexithymia is related to differences in gray matter volume: A voxel-based morphometry study. *Brain Research*, 1491, 60–67.
6. Donges, U., Kugel, H., Stuhrmann, A., Grotegerd, D., Redlich, R., Lichev, V., Rosenberg, N., Ihme, K., Suslow, T., & Dannlowski, U. (2012). Adult attachment anxiety is associated with enhanced automatic neural response to positive facial expression. *Neuroscience*, 220, 149–157.

Poster

1. Lichev, V., Suslow, T., Ihme, K., Quirin, M., Rosenberg, N., Sacher, J., Villringer, A., Rufer, M., Grabe, H., Kersting, A., & Lane, R. Automatic facial expression processing as function of Alexithymia: An fMRI Study. 1st

Conference of the European Society for Cognitive and Affective Neuroscience (ESCAN), Marseille, Mai, 9-12 2012.

2. Lichev, V., Donges, U-S., Ihme, K., Rosenberg, N., Suslow, T., & Kersting, A. Intero- und exterozeptive Wahrnehmung von Affektivität bei Adipositas: eine Übersicht. Jahrestagung der Deutschen Gesellschaft für Psychiatrie, Psychotherapie und Nervenheilkunde (DGPPN), Berlin, November, 23-26 2011.
3. Lichev, V., Rosenberg, N., Kersting, A., & Suslow, T. Bindungsvermeidung und automatische affektive Reaktion auf Gesichtsausdruck. Research Festival, Leipzig, Dezember, 15 2010.
4. Lichev, V., Wolfradt, U., & Paelecke, M. Interkulturelle Unterschiede in der Emotionsregulation. 12. Kongress der Deutschen Gesellschaft für Verhaltensmedizin und Verhaltensmodifikation (DGVM), Leipzig, Oktober, 1-3 2009.

Keynotes

1. Lichev, V. Kognitive Emotionsregulation, Depressivität und Depersonalisation: Eine interkulturelle Studie. Vortrag auf der Pierre Janet Tagung Halle, November 2012.

Erklärung über die eigenständige Abfassung der Arbeit

Hiermit erkläre ich, dass ich die vorliegende Arbeit selbständig und ohne unzulässige Hilfe oder Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe. Ich versichere, dass Dritte von mir weder unmittelbar noch mittelbar geldwerte Leistungen für Arbeiten erhalten haben, die im Zusammenhang mit dem Inhalt der vorgelegten Dissertation stehen, und dass die vorgelegte Arbeit weder im Inland noch im Ausland in gleicher oder ähnlicher Form einer anderen Prüfungsbehörde zum Zweck einer Promotion oder eines anderen Prüfungsverfahrens vorgelegt wurde. Alles aus anderen Quellen und von anderen Personen übernommene Material, das in der Arbeit verwendet wurde oder auf das direkt Bezug genommen wird, wurde als solches kenntlich gemacht. Insbesondere wurden alle Personen genannt, die direkt an der Entstehung der vorliegenden Arbeit beteiligt waren.

15.12.2014

Datum

B. Ince

Unterschrift

Acknowledgment

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Study 2: Supplementary Materials

In study 2 additional analyses were conducted to examine the behavioral and the neurobiological correlates of the automatic emotion processing as a function of two different alexithymia measures (i.e. TAS-20 and TSIA) and one of emotional awareness (i.e. LEAS). Due to space limitations these results were not included in the original article. Therefore, these results are exclusively reported in the present dissertation.

Table 1:

Table 1 shows correlations between alexithymia as measured with the interview and reaction times for the four emotional conditions (i.e. happy, neutral, angry and fearful). The positive correlations mean that alexithymia is related to prolonged decision latencies during the processing of happy and angry facial expressions. That is, individuals with increased alexithymia need more time to make evaluative judgments. No such correlations for TAS-20 or LEAS were observed.

Measure	TSIA	RT_Happy	RT_Neutral	RT_Angry	RT_Fearful
TSIA	--	0.25*	0,17	.25*	0,24
RT_Happy			.90**	.91**	.91**
RT_Neutral				.94**	.94**
RT_Angry					.95**
RT_Fearful					

Table 1: Note: * $p = 0.05$, ** $p = 0.01$ (1-tailed). Correlation between alexithymia (i.e. TSIA) and reaction times for the emotional conditions.

Figure 1:

Figure 1 shows shifts in implicit positive affect due to subliminally presented happy as compared to angry faces as a function of trait emotional awareness (LEAS) ($r = .40$ $p < .05$, two-tailed). In other words participants with more emotional awareness showed more prime valence congruent shifts in implicit positive affect. The shifts were calculated by subtracting implicit positive affect scores for the angry face condition from those of the happy face condition.

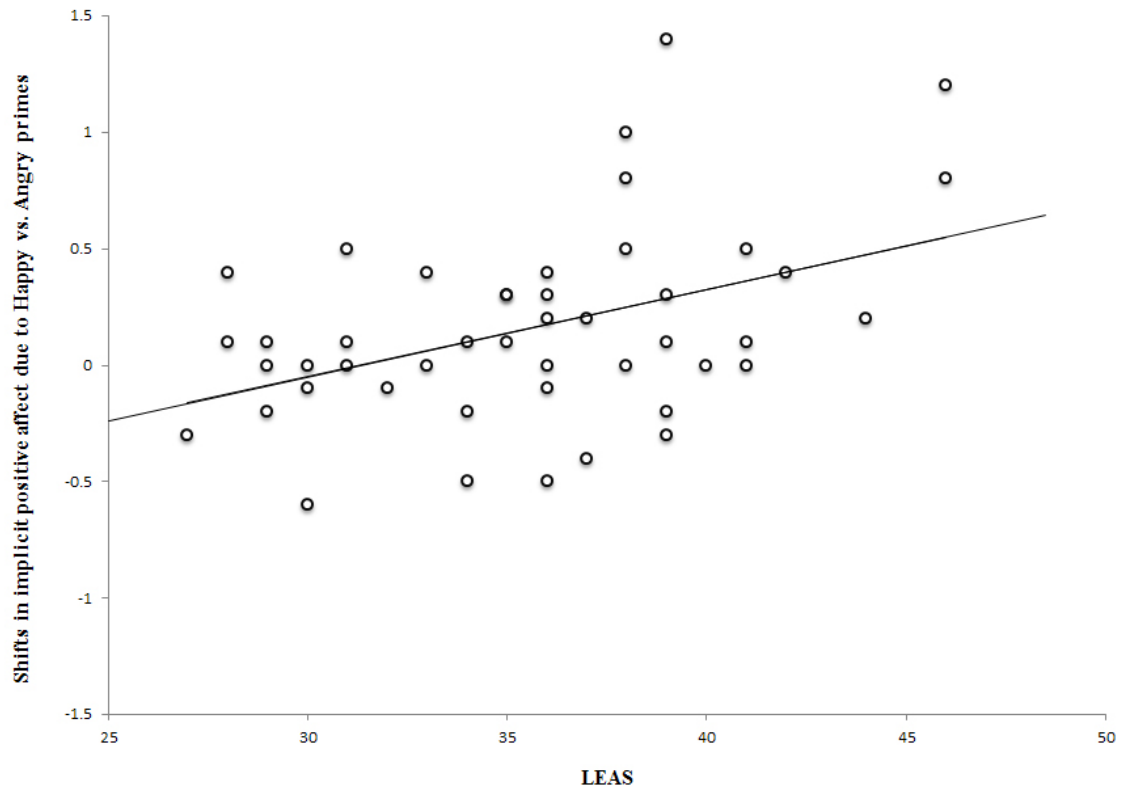


Figure 1: Correlation ($r = .40$ $p < .05$, two-tailed) between LEAS and shifts in implicit positive affect due to subliminally presented happy as compared to angry faces.

Both table 1 and figure 1 suggest that more objective measures such as LEAS and TSIA (but not the self-report instrument TAS-20) are better predictors of behavioral performance due to automatic emotion processing. This is in line with observations from personality research indicating that objective tests predict more spontaneous behaviors whereas self-report measures predict more controlled behaviors.

Figure 2:

Brain reactivity to masked happy faces as a function of trait emotional awareness and alexithymia controlling for trait positive affect. A: increased brain activation in amygdala, insula, fusiform gyrus, thalamus, superior temporal gyrus, primary somatosensory cortex, middle occipital gyrus, BA44, BA45, and BA47 as a function

of LEAS (red). B: decreased brain activation in BA47 as a function of TSIA (violet). C: decreased brain activation in primary somatosensory cortex, thalamus, superior temporal gyrus, and BA45 as a function of TAS-20 (green). Numbers represent the axial (z) coordinates of each slice. Results are displayed at $p = .05$ cluster corrected and overlaid on a Montreal Neurological Institute template brain.

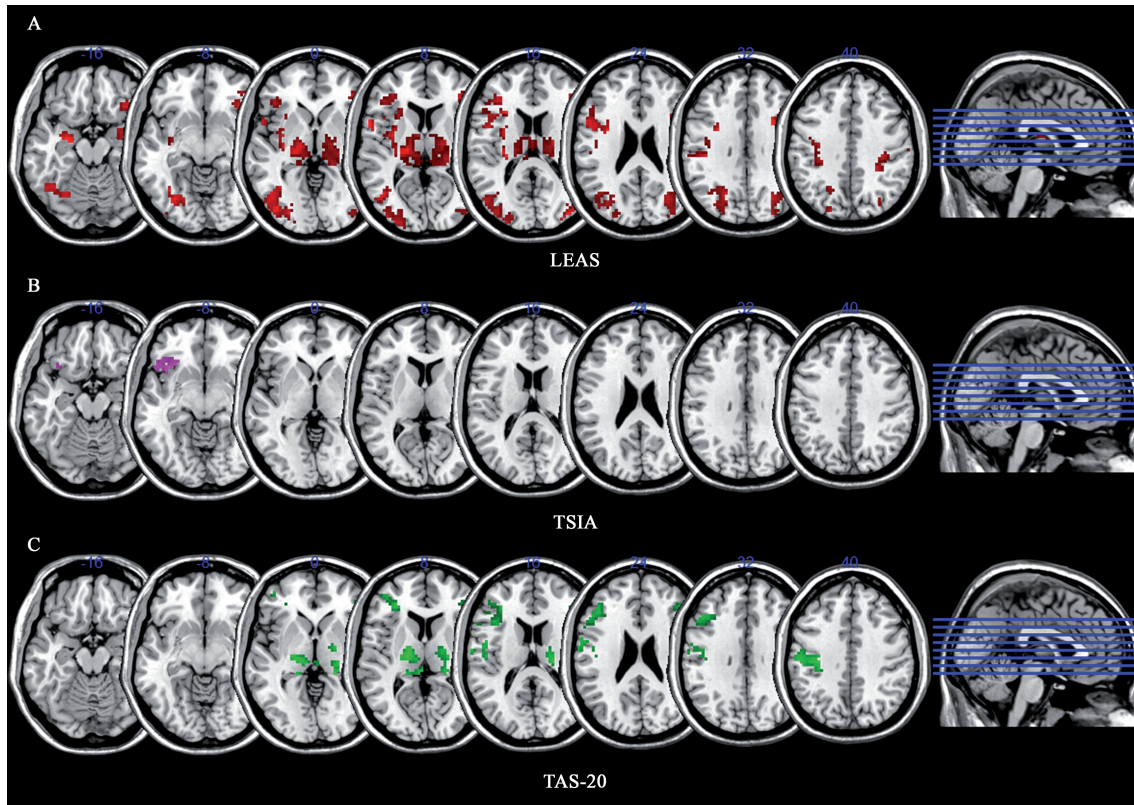


Figure 2: *Brain reactivity to masked happy faces as a function of LEAS (red), TAS-20 (green), and TSIA (violet).*

Figure 3:

Brain reactivity to masked angry faces as a function of trait emotional awareness and alexithymia controlling for trait positive affect. A: increased brain activation in amygdala, insula, thalamus, primary somatosensory cortex, and BA47 as a function of LEAS (red). B: decreased brain activation in BA47 as a function of TSIA (violet). C: decreased brain activation in amygdala, thalamus, middle occipital gyrus, and BA45 as a function of TAS-20 (green). Numbers represent the axial (z) coordinates of each slice. Results are displayed at $p = .05$ cluster corrected and overlaid on a Montreal Neurological Institute template brain.

Both figures suggest that trait emotional awareness is a better predictor of automatic brain response to facial emotions than trait alexithymia. However, the effect seems much stronger for the positive than for the negative emotions. Comparisons of the number of voxels with significant correlations show that trait emotional awareness predicted a total number of 4.825 voxels in ten predefined ROIs in both emotional

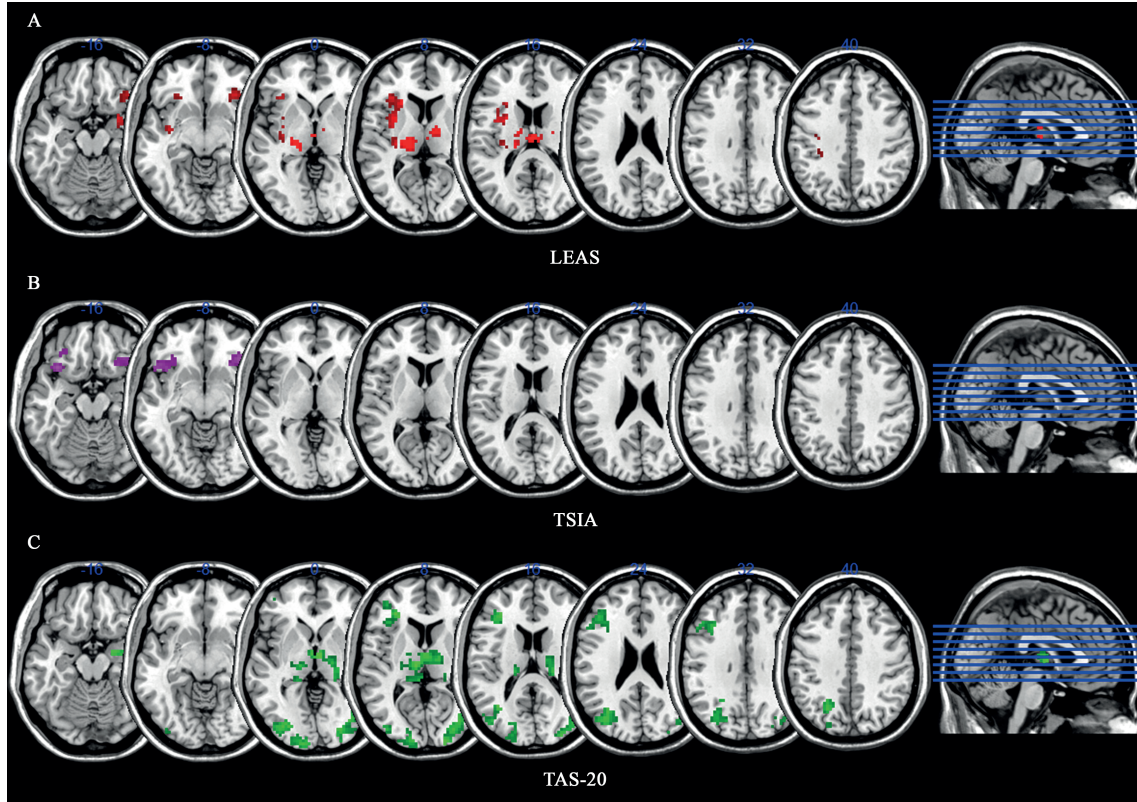


Figure 3: *Brain reactivity to masked angry faces as a function of LEAS (red), TAS-20 (green), and TSIA (violet).*

conditions (i.e. happy and angry). In contrast, both measures of alexithymia predicted a total number of 3.081 voxels in the same conditions. Thus, on average trait emotional awareness predicted about 165 voxels more (in each ROI) than alexithymia. This difference was significant, $t(9) = 1.91$, $p < .05$. Therefore, the results suggest that trait emotional awareness is a better predictor of neural responses to masked facial emotions than alexithymia.